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BULLETIN OF THE
U.S. DEPARTMENT OF AGRICULTURE

No. 150

Contribution from the Bureau of Soils, Milton S. Whitney, Chief.
January 23, 1915.

UTILIZATION OF THE FISH WASTE OF THE PACIFIC COAST FOR THE MANUFACTURE OF FERTILIZER.

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INTRODUCTION.

In pursuance of the investigation by the Bureau of Soils of the fertilizer resources of the United States, the fisheries of the Pacific coast, particularly the salmon-canning industry, were examined during the summer of 1913 to determine the possibility of developing a source of fertilizer materials in the waste produced in that industry. The purpose of this investigation was (1) to determine the amount of waste and the places where produced, and (2) the possibilities of its utilization as a source of fertilizer. Obviously, it is of little interest to know the fertilizer resources of the country without knowing how they may be utilized; the possibility of their utilization determines their value as resources. A third aspect was given the investigation by the problem of determining possible ways in which waste fish could be conserved in conjunction with that other vast source of fertilizer materials, now practically untouched, the giant kelps of the Pacific coast.

Note.—This bulletin discusses the utilization of fish waste in the salmon-canning and similar industries on the Pacific coast as a source of fertilizer material.

In a previous report on the Menhaden Fish Fertilizer Industry of the Atlantic coast,[1] the fish-fertilizer resources of the Atlantic coast have been discussed. In the introduction to that report the contributions from this bureau on the subject of fertilizer resources of the Nation are mentioned. Since the completion of that report, Waggaman has reported on the phosphate fields of South Carolina,[2] the utilization of acid and basic slags in the manufacture of fertilizer,[3] and the possible commercial utilization of nelsonite.[4] Free has described the topography of the desert lake areas,[5] while Young has discussed the chemistry of the salines of that region.[6] Crandall has continued his study of the kelps of southern California, and Frye[7] and Rigg,[8] during the summer of 1913, surveyed the kelp groves of southeastern and western Alaska, respectively. Cullen, Lindemuth, Merz, and Parker have studied further the composition of kelps.[9] Cameron has reviewed the sources of potash in the United States.[10] Ross has studied the decomposition of feldspar,[11] and Smith the value of sponges as fertilizer.[12] Gardiner has determined the potash content of certain muds from sugar refineries,[13] and the writer has surveyed the nitrogenous resources of the United States.[14]

Present agricultural practice prescribes the use of three chemical elements as a "soil amendment," a "stimulant for plant growth," or a "plant food," as it is variously put. These three elements when applied to the soil in which a crop is growing have been found by practice to afford an increased crop yield. They are phosphorous, potassium, and nitrogen, spoken of by the respective trade terms of phosphoric acid, potash, and "ammoniates." In the commercial fertilizers phosphoric acid is found in the form of calcium phosphate, which is bone phosphate or rock phosphate, usually treated with sulphuric acid to render it soluble. Potash is found as a salt or salts of potassium, either sulphate or chloride, and the "ammoniates,"

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[1] Bul. 2, U. S. Dept. of Agr.

[2] Bul. 18, U. S. Dept. of Agr.

[3] Bul. 95, U. S. Dept. of Agr.

[4] J. Ind. Eng. Chem., 5, No. 9, Sept., 1913.

[5] Bul. 54, U. S. Dept. of Agr.

[6] Bul. 61, U. S. Dept. of Agr.

[7] Rept. 100, U. S. Dept. of Agr., Parts IV and V.

[8] Ibid.

[9] J. A. Cullen, On the Available Nitrogen Content of Kelp, J. Ind. Eng. Chem., 6, 581 (1914); Merz and Lindemuth, The Leaching of Potash from Freshly Cut Kelp, J. Ind. Eng. Chem., 5, 729 (1913); Merz, On the Composition of Giant Kelps, ibid., 6, 191 (1914); Parker and Lindemuth, Analyses of Certain of the Pacific Coast Kelps, ibid., 5, 287 (1913).

[10] Possible Sources of Potash in the United States, Yearbook, U. S. Dept. Agr., 1912, p. 523; Kelp and Other Sources of Potash, J. Frank. Inst., Oct., 1913, p. 347.

[11] Decomposition of Feldspar and Its Use in the Fixation of Atmospheric Nitrogen, J. Ind. Eng. Chem., 5, 725 (1913).

[12] Sponges as a fertilizer, ibid., 5, 850 (1913).

[13] Ibid. 6, 480 (1914).

[14] Turrentine, The Nitrogenous Fertilizers Obtainable in the United States, Bul. 37, U. S. Dept. of Agr.

as the inorganic salt of ammonia, ammonium sulphate, the inorganic salts of nitric acid, sodium nitrate, and inorganic compounds of nitrogen, calcium cyanamid, or the organic compounds of nitrogen, contained in animal or vegetable refuse matter, cottonseed meal, abattoir tankage, or fish scrap. The usual commercial fertilizers contain these three elements and have the designation of "complete fertilizers." These are sold under various brand names, the various brands frequently being recommended for particular crops. The proportion of the three essential ingredients is varied; as a usual thing that of the phosphoric acid is considerably higher than the other two, which are present in about the same proportion. Thus, for example, a "6–2–2 mixture" contains 6 per cent phosphoric acid (P_2O_5), 2 per cent ammonia (NH_3), and 2 per cent potash (K_2O). Its selling price in the retail market is based on its analysis. Little attention is paid to the source of these ingredients so long as the essential compounds are "available," or readily may be decomposed or made soluble for the use of the plants.

The Nation's supply of these three common ingredients of fertilizer may be summarized as follows: Of phosphoric acid there is an abundant supply in the large deposits of phosphate rock in Florida and Tennessee, and the enormous deposits of Idaho, Montana, and Wyoming. Of potash, now obtained exclusively from the German mines, there is little known in this country outside of the desiccated residues in Searles Lake, Cal., and the giant kelps of the Pacific littoral. In the latter there is much more than enough to supply the present demands of the fertilizer trade of the United States, the present annual consumption of potash being about 1,250,000 tons, of varied composition. At present the kelps are not supplying any of this, since it has not been determined by actual experimentation on a commercial scale that they can be used economically as a source of potash. Estimates based on costs of similar operations indicate that they can be so used. Of "ammoniates" there is a large source in the ammonia produced as a by-product in the distillation of coal for the production of gas or coke, or both. This source is but partially developed, as by the methods most commonly practiced in this country this possible by-product is not recovered. The amount of ammonia now going to waste is almost large enough to supply all of the "ammoniates" now demanded by the fertilizer trade. The abattoirs supply a large amount of tankage and dried blood of high fertilizer value; but of these possible by-products there is still an enormous loss through the lack of organization and cooperation in the small-scale slaughter of animals for food.

The present consumption of the various "ammoniates" and their relative contribution to the total amount of nitrogen used in the fertilizer industry are shown in the table following.

TABLE I.—*Sources of nitrogen used in mixed fertilizers of the United States. (Figures are approximations.)*

Material.		Amount used in United States.	Nitrogen content.	Nitrogen yielded.
		Tons.	*Per cent.*	*Tons.*
Ammonium sulphate		215,000	19.75	42,463
Sodium nitrate (Chilean)		85,000	15.5	13,175
Calcium cyanamid		.....	18.0	.....
Cottonseed meal	High	681,000	6.5	44,272
	Low	388,000		24,320
Fish scrap		70,000	9.0	6,300
Tankage	High	162,000	6.5	10,500
	Low	99,000		6,450
Dried blood	High	57,500	11.0	6,300
	Low	37,700		4,150

This report is designed for the information of the layman who is totally unfamiliar with the fish industries of the Pacific coast, of those familiar with the fishing industries but not familiar with the fertilizer trade, and particularly of those who are interested in the manufacture of fertilizer from fish waste. For this reason all phases of the subject are discussed, some of them in such detail as possibly to appear extreme to those familiar with these details. Where such details are omitted from this report, the literature containing them, generally easily accessible Government reports, is referred to where possible. The apparatus for use in rendering fish waste is discussed in greatest detail, because, of all the items conneced with the industry herein proposed and advocated, this is considered the one on which information is most apt to be lacking and therefore most likely to be desired. The writer has been assured of the willingness and the desire of many of the operators of canneries to conserve the by-products now lost as soon as they are informed of the proper methods and apparatus to be used. An especial effort therefore is made to present all available information concerning these, and to discuss fully their advantages and disadvantages.

TECHNOLOGY OF CANNING.

FISHING.

Salmon for use by the canneries are caught in traps or pound nets, purse seines, haul seines, gill nets, and fish wheels. In southeast Alaska the greater portion of the fish are taken in traps, owned and operated by the packers, while in the Puget Sound region many are caught with purse seines and gill nets. On the Columbia River drag seines, gill nets, and fish wheels are in general use.

TRAPS.

The traps or pound nets are designed to intercept the fish as they swim in courses paralleling the shore or passing certain points. For

this purpose a "lead" is built, consisting of a line of net or woven wire supported on piles or posts and extending from a height slightly greater than that reached by high water to the bottom. It extends at right angles to the shore outward to a suitable depth.

The fish, in moving along the shore, encounter the "lead" and turn outward toward deep water to pass around the obstruction. To intercept them the trap proper is provided with a V-shaped entrance designed to lead them, as they swim outward, into the trap. This, from its shape, is spoken of as the "heart" of the trap. The outer ends of the two branches of the V are provided with "jiggers," an inward extension of the ends of the limbs of the V, so constructed as to divert back into the "heart" the fish seeking to escape around them. The apex of the first heart enters a smaller and supplementary heart of similar shape, which terminates at its apex in an elongated, constricted portion of its netting, called the "tunnel," and enters the "pot." The "pot" is a cubical compartment, which may be joined on one or both sides, by means of a shorter "tunnel," with the "spiller." The latter receives the captured fish and acts as the receptacle from which they later are unloaded from the trap.

The trap usually is constructed of piles driven into the bottom. These are connected at the top by stringers. Upon the piles and supported by the stringers is stretched the net constituting the walls of the various compartments. The bottom or floor of the heart slopes upward toward the "tunnel." This, by leading the fish swimming near the bottom up into the trap, obviates the necessity of extending the subsequent compartments of the trap entirely to the bottom. These then are built only to a convenient depth; they are floored as well as walled with net.

A later modification of the trap, designed to do away with the expense of driving piles, or for use in locations not suitable for pile driving, is the floating trap. The shape of the floating trap essentially is the same as that of the stationary trap. It is constructed of a staunch framework of logs bolted together, which floats and from which extend sections of iron pipe to support the requisite nets. The lead likewise floats. It is a string of logs beneath which woven wire is stretched between sections of iron pipe supported by the logs. The whole is securely anchored in position.

A trap which is catching fish is said to be "fishing." The captured fish are transferred to a scow for conveyance to the cannery. To load, the scow is made fast to the pilings supporting the "spiller"; or, in the case of the floating trap, to the logs constituting the supporting frame of the "spiller." The "tunnel" from the "pot" to the "spiller" is closed and the walls of the latter are dropped almost to the surface of the water. (See Pl. I, fig. 1.)

The fish are transferred from the trap to the scow by means of the "brailer" (Pl. I, fig. 2), which is a stretch of net perhaps 20 feet long by 10 feet wide. One end is made secure to the side of the scow nearest the trap. To the other end are attached three lines, the central one of which extends through the block at the top of a derrick rigged on a tug drawn alongside and is made fast to the capstan on the deck of the tug. The other two are held in the hands of two operators stationed in a dory within the "spiller" compartment of the fish trap. The "brailer" is weighted at its movable end with an iron rod or section of iron pipe and also by short sections of chain distributed at proper intervals along its edge.

In operation, the line from the capstan on the tug is played out, whereupon the "brailer" falls into the "spiller" and is sunk by its own weights. The two men in the dory then pull upon their lines and straighten out the "brailer" in a horizontal position beneath the mass of fish. At a signal the "brailer" is hoisted to a perpendicular position by the line running to the tug, and the fish lifted by it slide or tumble into the scow, to the side of which the "brailer" is attached. This operation is repeated until the "spiller" is emptied or until the scow is filled. The writer has witnessed the filling of a scow of 30,000 fish capacity within an hour and a quarter.

Perhaps one of the greatest advantages, to the packers, of the fish trap lies in the fact that the fish in the traps are kept in moving water and alive and therefore fresh until they are needed at the cannery. This is of particular advantage in the height of the canning season when fish are abundant and are being received at such a rate as to tax the capacity of the cannery. The fish traps may be drawn upon when fish from the seine fisheries are not immediately available.

PURSE SEINES.

The purse seine, so called because it is provided with a line run through rings at the bottom by which it may be closed as a purse with a draw string, is about 1,000 feet long by 125 to 150 feet in width. Rings of galvanized iron strung along its bottom serve both as weights to keep it stretched and to receive the purse line.

The seine is operated in such manner as to inclose the school of fish, and is then closed at the bottom. To accomplish this, when a school of fish is sighted, one end of the seine is held in a dory while the main length of it is played out from a power boat, which pursues a course encircling the school. When the circle has been completed and the power boat has returned to the dory, the purse line is drawn in by a power winch and the slack in the seine is taken aboard until the fish are forced into a small compass. They are then "brailed" or dipped into the boat, transferred by means of a "gaff," or the mass of fish is drawn aboard while still inclosed in the pursed seine.

HAUL SEINES.

This type of seine may vary in length from 500 to 2,500 feet. In its center is a baglike section, sometimes called the "bunt," which may be about 300 feet in length. Two boats are required to operate the seine, one a dory, which holds the more nearly stationary end of it, and the other a large seine boat, which carries the seine and plays it out in such manner as to encircle the fish. The dory approaches the shore directly, while the seine boat approaches it after completing a wide curve in the water. The seine usually is drawn ashore, most frequently upon a favorably sloping sandbar, by means of horses.

This method of fishing is adapted only to locations where a smooth and gently sloping shore is available, so that the seine can be hauled in promptly and easily before the fish have escaped. It most frequently is seen in use on the Columbia River.

GILL NETS.

The size and shape of gill nets are determined by the characteristics of the body of water in which they are to be used, and the dimensions of the meshes by the size of the salmon to be caught. The net is supported by corks and is kept distended by leads attached to the bottom. It is stationed in the tidal or river current in such manner as to form the letter "L," with the end of the longer branch against the shore and the other flowing loose in the current. As the position of the net is usually maintained by the current without the assistance of stakes, where the current is tidal the net is placed at the beginning of a tide and is taken in before a change in the direction of flow occurs. As the success of this manner of fishing depends on the entanglement of the fish in the meshes of the net, it can be applied only under those conditions whereby the net is rendered invisible to the fish, in muddy water or at night.

At the end of the fishing period the seine is pulled aboard the boat of the attendant, the enmeshed fish being removed as the net is drawn in. The same form of net may be made fast in the stream by stakes or other anchorages and may be allowed to "fish" as long as the attendant sees fit.

Perhaps the greatest objection to this form of fish-taking apparatus lies in the fact that the enmeshed fish are killed, probably immediately, and are permitted to remain suspended in the water for an unknown period. The fact certainly can not be regarded as enhancing the value of the fish, and may render the fish undesirable for food.

FISH WHEELS.

Fish wheels are designed to catch the salmon on their course up the rivers in which the wheels are placed. They are of various

dimensions and methods of construction, being built in that shape and size best adapted to their respective locations. In size they vary from about 10 feet to about 30 feet in diameter and in width from about 5 to 15 feet. The wheel is so mounted, either in a permanent structure built out from the shore or upon rocks in midstream, or upon a scow, which can be anchored in the desired situation, that it is submerged partially in the water. The flow of the stream causes the wheel to revolve. "Buckets" of woven wire are built in the wheel in such a manner that as the wheel revolves they pass through the water as scoops, picking up the fish. Frequently series of piles are built extending out into the stream in such a way as to direct the fish into the wheel. Mounted in the axis of the wheel, or in some other suitable manner, is a trough-like receptacle for the fish. This is frequently built so as to empty into a scow. The curve of the scooplike bucket of the wheel is such that as the wheel revolves and the bucket is lifted, the fish in the bucket are made to slide toward the axis and finally to fall into the trough.

This manner of fishing is practically automatic. During the season in which the salmon are moving upstream the method is satisfactory for supplying the demands of the packers. One hears reports of scows being sunk by fish taken during a night's operations.

The catch of salmon in Alaska by the three principal forms of gear—seines, traps, and gill nets—is shown in the following table:[1]

TABLE II.—*Percentage of total catch of salmon by the three principal forms of gear used in Alaska, for the year 1913.*

Apparatus.	Section of Alaska.		
	Southeastern.	Central.	Western.
	Per cent.	*Per cent.*	*Per cent.*
Seines	48	47	2
Traps	50	46	4
Gill nets	2	7	94

UNLOADING.

The salmon are unloaded at the canneries (Pl. II, figs. 1 and 2) by being pitched, generally on two-pronged forks, into an elevator which deposits them upon the floor of the house in which they are to be cleaned. (Pl. III, figs. 1 and 2.) Here they are sorted into grades. As they lie in piles upon the floor streams of fresh water—in Alaska frequently icy cold and of a high degree of purity—are directed upon them.

[1] Bower and Fassett, The Fishery Industry of Alaska in 1913. Pacific Fisherman, 12, No. 1 (Special), 54 (1914).

FIG. 1.—CAPTIVE SALMON IN THE "SPILLER" OF A TRAP.

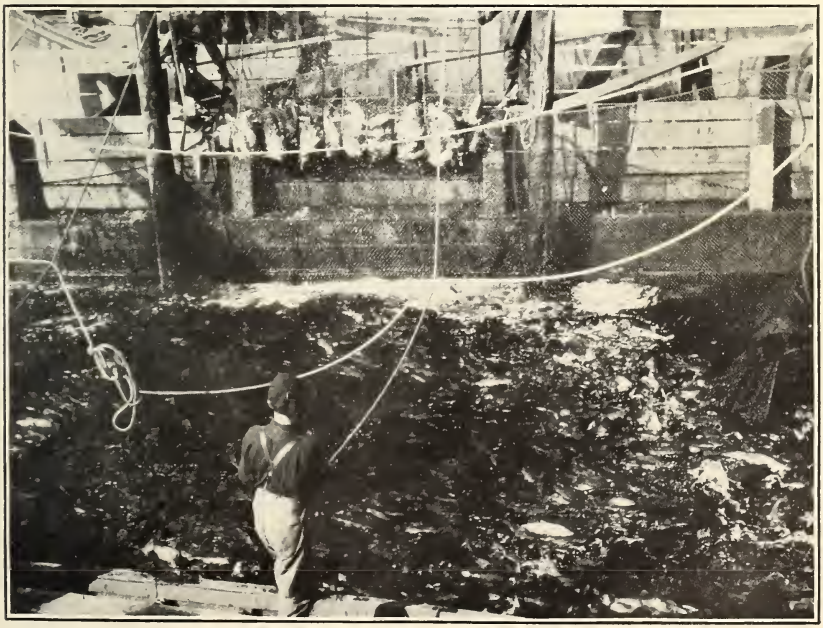

FIG. 2.—"BRAILING" SALMON FROM A TRAP.

The freshly caught fish are not regarded as being in the best condition for canning. It is said that the flesh is elastic and will not remain compressed in the cans. For this reason it is difficult to put into a can the requisite weight of fish, and many light-weight cans result. Therefore the fish are allowed to lie about 24 hours before being canned. When, as frequently happens, they are hauled long distances, from the trap or seining grounds to the cannery, the length of time they are allowed to remain on the canning floor is brief or negligible. In warm weather, or in a warm climate, to permit the fish to remain unchilled for such a length of time would result in their deterioration. In Alaska at least, where the weather, even in the summer, is much of the time cold and rainy, little detriment probably is caused by their seasoning period of 24 hours, especially where they are kept thoroughly washed in cold weather.

From the floor of the cleaning house the salmon are pitched upon a table by means of "pews" or one-tined forks. (Pl. IV, fig. 1.) This is generally thrust into the head, but frequently into the body, of the fish. Upon this table the fish are arranged in order and passed on to the "butchers."

CANNING.

DRESSING.

Formerly the cleaning or butchering was done by Chinamen, and in some canneries this practice is continued. In most instances, however, cleaning by hand has been supplanted by machine cleaning.

The mechanical cleaner is spoken of in the parlance of the cannery as the "iron chink" (Pl. IV, fig. 2), a name which originated from the pseudo name of its human predecessor. Without entering into a detailed description of this machine, it is sufficient to say that it essentially is a revolving disk or wheel about 2 feet in diameter, around which knives and stiff brushes are arranged. These work together to split the fish along its belly, to remove its viscera, and to sever its fins, and finally its tail.

The machine is fed by two laborers, the first of whom places a fish under a stationary knife, against which it is lifted mechanically. The second laborer thrusts the beheaded fish into a slot, of which there are a number on the peripheral rim of the wheel, tail first, so that it becomes wedged and is held firmly. It thus is lifted and carried around, belly outward, by the wheel, and is brought successively against the knives and brushes. Abundant jets of water are made to play upon the fish as it passes through the machine.

This contrivance works rapidly and fairly successfully, with a rated capacity of 50 fish per minute and an actual output of 36 dressed fish per minute. It thus is possible to do away with the

large force of skilled and high-waged dressers. Fish are by no means uniform nor rigid objects; therefore no machine can be expected to adapt itself to the variation in size and the manner in which they pass through the machine. As the fish are not dressed uniformly by the machine, they subsequently must be passed under the knives of the "slimers," laborers whose duty it is to finish the work left incomplete by the machine. As the number of these about equals the number of "butchers" which would be required if the dressing were done altogether by hand, there is not the economy in labor resulting from the use of the mechanical cleaner that would be expected. The fact that much less skill is required of "slimers" than of "butchers," however, is an item greatly in favor of the use of the mechanical cleaner.

CUTTING.

After being thoroughly cleaned, the fish are cut into pieces of convenient size for filling the cans. A mechanical cutter of simple design has been adopted for this purpose. It consists essentially of a short conveyor which is made to revolve over bearings in such a way as to describe an ellipse. Blocks of wood are placed at intervals to carry the fish. At the apex of the ellipse revolving knives are placed. These revolve in horizontal slits in the conveyor and blocks. As the blocks start on their upward course the fish are placed upon them by hand and are carried through the knives. The distance between the knives is such that the fish are cut into sections of the proper length to fill cans of the size for which they are intended.

FILLING THE CANS.

Cans designed to hold a pound of fish are filled usually by a machine which, by means of a plunger, thrusts into the can pieces of salmon already cut to the right length and trims off that which projects. As the thrust of the plunger is uniform, the machine is able to load the cans with a nearly exactly uniform weight of fish, and works rapidly. Less than a second is required in filling a can. From the filler the cans are passed along a table, where they are inspected for short weight. Smaller cans are filled by hand. Their shallowness makes them less adapted to the filling machine, as they do not retain their charge of fish so readily.

After filling, it remains to cap the cans or put the lids on, cook the contained fish, seal, clean, and label. The canning process involving the use of soldered cans has been supplanted almost entirely by that based on the use of the solderless or so-called "sanitary" can. The latter process, being almost entirely automatic, effects a great saving in labor as well as floor space, and is commendable from both a mechanical and a sanitary point of view.

The modern cannery is equipped with machinery in units. A unit is spoken of as a "line." The one-line cannery is equipped with a mechanical cleaner or "iron chink," a cutter, a filling machine, a capping machine, followed by a steam box for the preliminary cooking before sealing, two crimping machines[1] for fastening the caps to render the can air-tight, and the requisite steam autoclave capacity for the final cooking. Such an equipment gives a daily capacity of 900 cases of canned salmon, each case containing 4 dozen 1-pound cans, or 48 pounds of canned salmon. This estimate is based on a day of about 12 hours. During the canning season a "one-line" cannery, or one with a single unit, is expected to pack about 40,000 cases. The season's pack is determined by the skill of the management, the condition of the market, and the fortune of the fishermen.

LABOR.

As many of the salmon canneries of Alaska are situated in isolated and scarcely habitable places, laborers have to be imported. In southeastern Alaska the natives are employed to a large extent, as the men seem to prefer and to be more successful at fishing; they are not found engaged in the indoor occupations to the extent that might be expected. Women and children are employed in large numbers in the canneries, performing the light and easy tasks such as inspecting the cans for underweight, labeling, and packing, and, where the filling machine is not employed, filling the cans by hand. For this class of work the women receive 25 to 30 cents per hour and the children about half that sum. The industry of the Alaskan native is surprising to one who is accustomed to associate extreme indolence with the American aborigine. That no part of the canning industry is too complex for the skill of the Alaskan native is abundantly illustrated by the operation of the cannery at Metlakahtla, which is run on a cooperative basis. During the fishing season, entire villages may be deserted, and it is no uncommon sight to see entire families at work, the men at the fishing grounds and the women and children in the canneries.

This native labor is made use of so far as possible, but is entirely inadequate to meet the demands of the industry, therefore labor must be imported. The prevailing nationality thus imported probably is Chinese; there are also Filipinos, Mexicans, Japanese, and other races in smaller numbers. The laborers are hired in gangs, generally on a contract basis. The contractors most frequently are Chinese, and the contract binds the contractor to pack so many cases of salmon at a certain price. To a casual observer it appears that the industry has an abundance of laborers and that there are about two men

[1] The capping machine, the cooking box, and the two crimping machines constitute the solderless or "sanitary" canning apparatus proper.

for every position. This may be true or it may be only apparent, but after all it has but a slight bearing on the economy of the industry, as any superfluity in the number of laborers is paid for by the labor contractor and not by the packer.

Laborers are provided for but one shift per day; therefore the working day can not be considered to be of more than 12 hours. The cannery may operate for a longer period, as the various departments are not operated simultaneously. Thus the dressing gang invariably begins work before those attending to subsequent operations.

As the forces are organized with a view to the maximum daily pack of the cannery, there are usually more laborers than is actually necessary for the average daily pack. Furthermore there are many days preceding the rush of the season when there are no fish at all to pack. At this time there are many things to be done to get the cannery in readiness for the season's operations, conspicuous among which is the manufacture of the tin cans to hold the fish and the wooden cases to receive the packed cans. But on the whole it may be said that there are frequent periods when one part of the cannery force or another is idle.

The laborers are organized in the Pacific coast cities of the States and are taken to the canneries frequently in the ships of the operators. For those going to western Alaska it is practically impossible to obtain additions to their force during the operating season. Those operators situated in central and southeast Alaska are on or near steamship lines and can secure additions to their force on comparatively short notice. The former circumstance makes it necessary for the operators of the western Alaska district to "carry" their corps of employees from the time of their departure from the States to their return. This period includes the time consumed in the ocean voyage in a sailing vessel from the city of their departure to the scene of the summer's activity.

PRODUCTION OF CANNED SALMON.

The number of cases of canned salmon packed on the Pacific coast during the season of 1913 is shown, by grades, in Table III.[1]

[1] Pacific Fisherman, 12, No. 1 (Special), 36 (1914).

TABLE III.—*Pacific coast canned salmon pack for 1913.*

District.	Kings, springs, chinooks.			Reds, sockeyes, bluebacks.			Medium reds, cohoes, silversides.		
	1-pound talls.	1-pound flats.	½-pound flats, 8 dozen.	1-pound talls.	1-pound flats.	½-pound flats, 8 dozen.	1-pound talls.	1-pound flats.	½-pound flats, 8 dozen.
Alaska	32,840	.....	1,327	1,917,961	17,628	28,790	73,218	721	3,438
Puget Sound	716	518	.....	967,119	485,426	220,554	20,440	38,354	2,225
Columbia River	28,738	96,633	66,745	.....	.....	11,152	10,437	19,408	11,124
Sacramento River	.....	950	.....	.....	.....	.....	.....	.....	.....
Outside streams	4,827	6,957	4,172	13,458	5,778	3,381	24,011	12,893	13,942
Total American pack	67,121	105,058	72,244	2,898,538	508,832	263,877	128,106	71,376	30,729
British Columbia	34,282	1,579	5,188	290,063	270,368	411,747	52,937	7,946	8,939
Total pack of entire coast	101,403	106,637	77,432	3,188,601	779,200	675,624	181,043	79,322	39,668

District.	Pinks, humpbacks.			Chums.			Steelheads.			Total.
	1-pound talls.	1-pound flats.	½-pound flats, 8 dozen.	1-pound talls.	1-pound flats.	½-pound flats, 8 dozen.	1-pound talls.	1-pound flats.	½-pound flats, 8 dozen.	Full cases.
Alaska	1,377,586	4,766	20,564	261,161	5,668	825	.....	.....	.....	3,746,493
Puget Sound	761,776	17,167	12,943	54,100	2,125	.....	.....	.....	.....	2,583,463
Columbia River	.....	.....	.....	13,181	.....	122	1,137	3,785	4,017	266,479
Sacramento River	.....	.....	.....	.....	.....	.....	.....	.....	.....	950
Outside streams	4,141	159	177	17,349	316	.....	600	.....	.....	112,161
Total American pack	2,143,503	22,092	33,684	345,791	8,109	947	1,737	3,785	4,017	6,709,546
British Columbia	148,799	12,928	31,160	76,369	1,596	.....	.....	.....	.....	1,353,901
Total pack of entire coast	2,292,302	35,020	64,844	422,160	9,705	947	1,737	3,785	4,017	8,063,447

CENTERS OF THE INDUSTRY.

The salmon-packing industry of the United States is centered mainly in four localities: The Columbia River, Puget Sound, southeastern Alaska, and western Alaska or the Bristol Bay region. The industry along the Columbia River is distributed from The Dalles, Oreg., to the mouth of the river, though the greatest number of canneries is located near the mouth of the river, in the neighborhood of Astoria. On Puget Sound, the industry is centered around Bellingham, Anacortes, and Port Townsend; there is an additional number of canneries in the Grays Harbor vicinity, on the Straits of Fuca. In southeast Alaska the canneries are distributed over the large area of islands and fiords extending from the Icy Straits to Dixon Entrance. In western Alaska they are situated principally on Bristol Bay. The locations of the various canneries in Alaska are shown in figures 1 and 2.

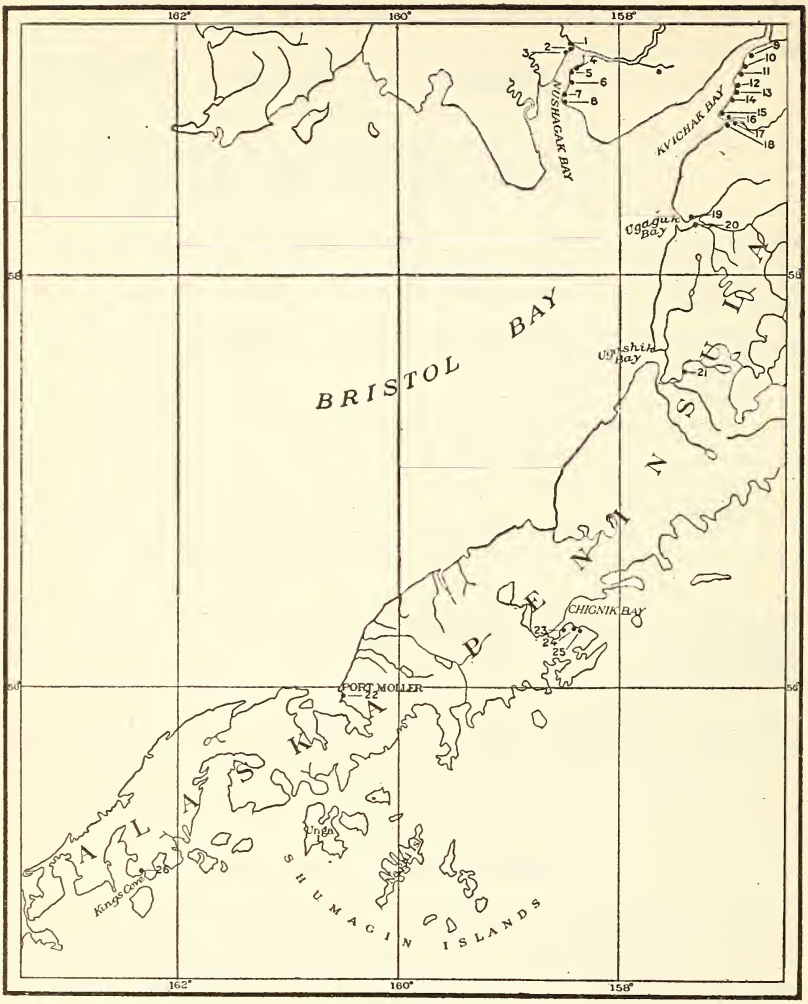

FIG. 1.—Sketch map showing location of the canneries on the peninsula of Alaska.

KEY TO LOCATION OF CANNERIES.

1. Alaska Salmon Co., Nushagak Bay (Wood River).
2. Alaska Portland Packers' Association, Nushagak Bay (Wood River).
3. Alaska Packers' Association, Nushagak Bay (Wood River).
4. Northwestern Fisheries Co., Nushagak Bay (Wood River).
5. Alaska Fishermen's Packing Co., Nushagak Bay (Wood River).
6. Columbia River Packers' Association, Nushagak Bay (Wood River).
7. Alaska Packers' Association, Nushagak Bay (Wood River).
8. North Alaska Salmon Co., Nushagak Bay (Wood River).
9, 10. North Alaska Salmon Co., Kvichak River.
11, 12. Alaska Packers' Association, Kvichak River.
13. Alaska Fishermen's Packing Co., Kvichak River.
14. Bristol Bay Packing Co., Kvichak River.
15. Naknek Packing Co., Naknek River.
16, 17, 18. Alaska Packers' Association, Naknek River.
19. North Alaska Salmon Co., Ugaguk River.
20. Alaska Packers' Association, Ugaguk River.
21. Red Salmon Canning Co., Ugashik River.
22. Pacific American Fisheries. Port Moller.
23. Northwestern Fisheries Co., Chignik.
24. Columbia River Packers' Association, Chignik.
25. Alaska Packers' Association, Chignik.
26. Pacific American Fisheries, King Cove.

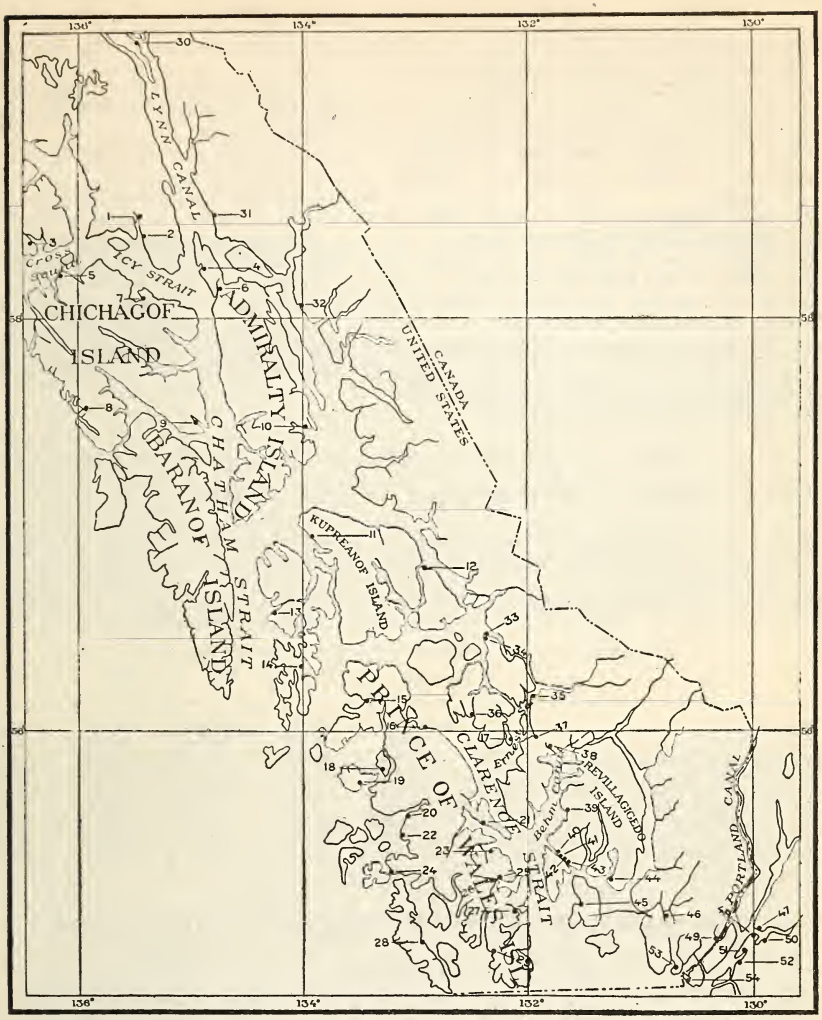

FIG. 2.—Sketch map showing location of the canneries in southeastern Alaska.

KEY TO LOCATION OF CANNERIES.

1. Pacific American Fisheries, Excursion Inlet.
2. Astoria & Puget Sound Packing Co., Excursion Inlet.
3. Northwestern Fisheries, Dundas.
4. Thlinket Packing Co., Hunter Bay.
5. J. B. Nelson (proposed).
6. Hawk Fish Co., Hawk Inlet.
7. Hoonah Packing Co., Hoonah.
8. Deep Sea Canning Co., Chicagof.
9. Geo. T. Meyers & Co., Chatham.
10. Admiralty Trading Co., Gambier Bay.
11. Kake Packing Co., Kake.
12. Pacific Coast & Norway Packing Co., Petersburg.
13. Pillar Bay Packing Co., Point Ellis.
14. Kuiu Island Packing Co.. Port Beauclerc.
15. Shakan Salmon Co., Shakan.
16. F. C. Barnes & Co., Lake Bay.
17. Canoe Pass Packing Co., Canoe Pass.
18. Irving Packing Co., Karheen.
19. Swift, Arthur & Co., Heceta.
20. North Pacific Packing & Trading Co., Klawack.
21. Kasaan Salmon Co., Kasaan.
22. Lindenberger Packing Co., Fish Egg.
23. Scowl Arm Packing Co., Scowl Arm.
24. Oceanic Packing Co., Waterfall.
25. Sunny Point Packing Co., Sunny Point.
26. Alaska Pacific Fisheries, Chomley.
27. Starr, Collinson Co., Moira Sound.

KEY TO LOCATION OF CANNERIES—Continued.

28. Wiese Packing Co., Rose Inlet.
29. Northwestern Fisheries, Hunter Bay.
30. Alaska Pacific Fisheries, Chilkoot.
31. Tee Harbor Packing Co., Tee Harbor.
32. Taku Canning & Cold Storage Co., Taku.
33. Alaska Packers' Association, Wrangell.
34. Alaska Sanitary Packing Co., Wrangell.
35. Point Warde Packing Co., Point Warde.
36. Sanborn, Cram Co., Burnett Inlet.
37. Northwestern Fisheries, Santa Anna.
38. Alaska Pacific Fisheries, Yes Bay.
39. Alaska Packers' Association, Loring.
40. Walsh, Moore Co., Ward Cove.
41. Revilla Fish Products Co., Ketchikan.
42. Pure Food Fish Co., Ketchikan.
43. Fidalgo Island Packing Co., Ketchikan.
44. Lindenberger Packing Co., Roe Point.
45. Metlakahtla Industrial Co., Metlakahtla.
46. Northwestern Fisheries Co., Quadra.
47. Kincolith Packing Co., Mill Bay, British Columbia.
48. British Columbia Packing Association No. 2, Nass Bay.
49. Hidden Inlet Packing Co., Hidden Inlet.
50. British Columbia Packers' Association, Nass Harbor, British Columbia.
51. Anglo-British Columbia Packing Co., Port Nelson, British Columbia.
52. Anglo-British Columbia Packing Co., Arrandale, British Columbia.
53. Herbert Hume, Nakat Inlet.
54. M. Des Brissay & Co., Wales Island, British Columbia.

In the following table is given the production of the various centers during the packing seasons 1909–1913, inclusive.[1]

TABLE IV.—*Production of canned salmon in the United States and Alaska, by districts, during the years 1909–1913, inclusive.*

District.	Number of cases packed.				
	1909	1910	1911	1912	1913
Puget Sound	1,632,949	567,883	1,557,029	416,125	2,583,463
Grays Harbor	19,787	51,130	61,671	54,507	54,922
Willapa Harbor	12,024	14,508	25,850	24,887	8,422
Columbia River	274,087	391,415	543,331	285,666	266,479
Oregon coastal streams	58,169	103,617	153,828	77,765	42,441
Klamath River, Cal	5,633	8,016	7,604	20,000	6,376
Southeastern Alaska	852,870	1,066,399	1,580,868	2,033,648	1,793,851
Central Alaska	391,054	432,517	499,743	625,062	477,267
Western Alaska	1,151,553	914,138	743,206	1,395,931	1,505,375

THE WASTE PRODUCED IN THE CANNING OF SALMON.

AMOUNTS.

The waste produced in the process of canning salmon is variously estimated to be from 25 to 50 per cent of the original or "round" weight of the fish. The percentage of waste varies with the kinds of salmon, being greater with small than with large fish. It probably is true also that in canning the more expensive grades, which also are the larger fish, greater precautions are taken to reduce the waste than with the cheaper grades. In the case of the larger fish—the "reds"—perhaps the portion thrown away is more nearly 25 per cent than 50 per cent. Therefore, in considering the problem of preparing the waste for use as fertilizer and in estimating the quantities of material available it must be specified what grades of fish are being dealt with.

[1] From statistics published by the Pacific Fisherman, January, 1914.

FIG. 1.—GENERAL VIEW OF AN ALASKAN CANNERY.

FIG. 2.—GENERAL VIEW OF AN ALASKAN CANNERY.

FIG. 2.—UNLOADING "HUMP-BACK" SALMON AT AN ALASKAN CANNERY.

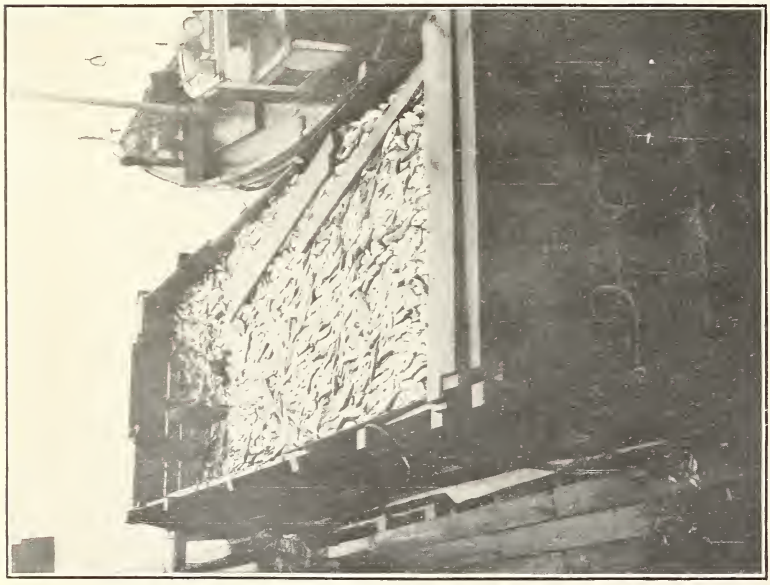

FIG. 1.—UNLOADING SALMON AT AN ALASKAN CANNERY.

FIG. 1.—INTERIOR OF FISH-CANNING ROOM OF AN ALASKAN CANNERY, SHOWING TWO "IRON-CHINKS" IN POSITION.

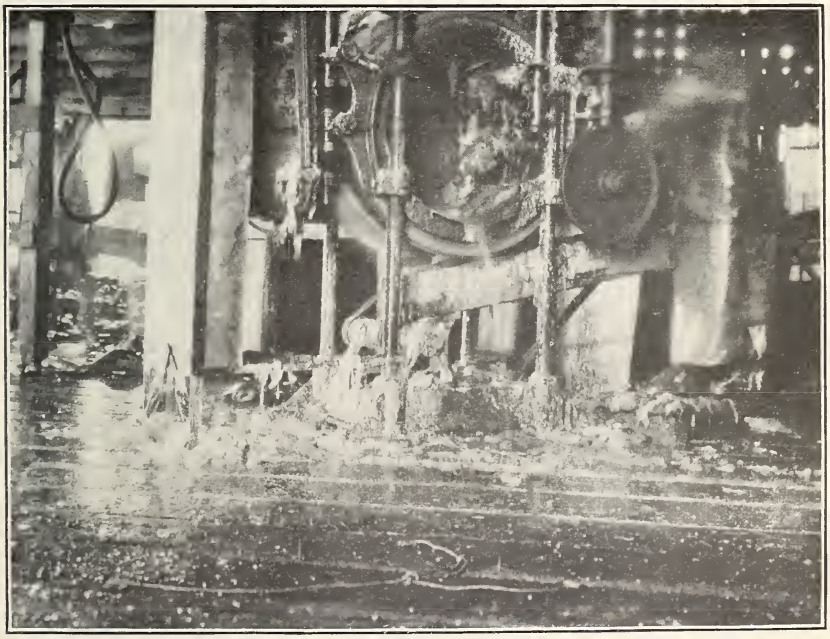

FIG. 2.—THE "IRON-CHINK" IN USE.

CANNERY WASTE EXPOSED AT LOW TIDE ON THE BEACH BENEATH AN ALASKAN CANNERY.

In general, it is sufficient to designate the region under consideration, as the various centers of the industry are characterized by certain grades. Thus, in the Bristol Bay region of Alaska the pack consists of 94 per cent red fish, or sockeyes. In southeastern Alaska, between Icy Straits and Dixon Entrance, the total pack contains about 1 per cent of "reds." In many canneries the proportion of red fish put up is negligible. In the Puget Sound region the composition of the pack varies with the year. In years of a large run of sockeyes, as in 1913, the pack may contain as much as 65 per cent of the red salmon. In other years, as in 1912, it may comprise only 45 per cent of sockeyes. In the three seasons preceding the last, 1910, 1911, and 1912, the average composition of the packs on Puget Sound was 22 per cent "reds." On the Columbia River the pack is composed almost entirely of red fish. While the figure which represents the exact proportions of waste from the red fish is not known, it can be said with a fair degree of accuracy that the waste from humpbacks is from 40 per cent to 50 per cent of the round weight. Thus, to fill a case of 48 1-pound cans, from 17 to 19 5-pound salmon are required. On this basis, a round weight of from 85 to 95 pounds is reduced to 48 pounds, representing a waste of from 37 to 47 pounds per case. For the sake of conservativeness in this discussion, 40 pounds per case has been taken to represent the waste from humpbacks and 30 pounds per case that from the "reds." On the basis of the foregoing figures representing the total pack of salmon, taking 30 pounds per case as representing the loss from red salmon and 40 pounds per case from the others, the amount of cannery waste produced by centers may be estimated. Likewise the value has been computed on the basis of $15 per ton, the value fixed by present commercial operations. The following table gives the amount of cannery waste and its value:

TABLE V.—*Amount of cannery waste produced and its value.*

Region.	Cases packed.		Waste.			Value.
	"Reds."	Others.	"Reds."	Others.	Total.	
			Tons.	*Tons.*	*Tons.*	
Columbia River	266,479	.....	4,000	.....	4,000	$60,000
Puget Sound	1,673,099	910,634	25,100	19,700	44,800	672,000
Southeastern Alaska	180,685	1,613,150	2,700	32,260	34,960	524,400
Western Alaska	1,419,441	85,934	21,290	1,700	22,990	344,850
Central Alaska	364,253	83,014	9,960	1,660	11,620	174,300
Grays Harbor, Willapa Harbor, and Oregon coastal streams	[1] 105,785	.....	1,540	.....	1,540	23,100
United States	.....	.....	.....	.....	119,910	1,798,650
British Columbia	[1] 1,353,900	.....	20,300	.....	20,300	304,500
Pacific coast	.....	.....	.....	.....	140,210	2,103,150

[1] Computed as "reds."

CHARACTER OF WASTE.

The first waste involved in the canning of salmon to be considered in this discussion is the waste of fish other than salmon taken with them in seines and traps. This varies widely from day to day and with the place and method of fishing. At best it is a matter of great uncertainty. Thus, in a scow load of 30,000 salmon taken from a trap under the observation of the writer, there was an entirely negligible number of fish other than salmon, while from another trap it was recorded that the catch was made up of approximately 50 per cent of salmon and 50 per cent of other fish. Of the salmon about 1 per cent was dog salmon, a slightly larger proportion was humpbacks, 10 per cent was cohoes, and the balance, about 88 per cent, was sockeyes. Among the other fish taken, a number equal to that of the salmon, were trout, tomcod, flounders, and dog fish. Where the proportion of fish other than salmon taken in traps is so great, they are thrown from the scow as fast as brailed into it; while if the proportion be small, they are permitted to remain. When the fish are unloaded at the cannery these are thrown overboard by the unloaders as encountered, or, frequently, the edible fish are picked out by children or adults from among the laborers around the cannery and are used for food. Aside from the fish so consumed, there is a considerable number of food fish for which there is no demand, as well as nonedible fish, such as dogfish, which easily could be made available as a supplementary source of material from which to prepare fertilizer and oil. However, from the casual observations of a summer spent in and around the salmon canneries and from the answers to casual inquiries regarding the matter, it must be said that as a source of such material the fish other than salmon, taken incidentally in the salmon fisheries, are too uncertain and too variable in amount to be given very serious consideration. Undoubtedly, in the aggregate they form a considerable supply, and a large part of it could be made available for fertilizer manufacture. But in view of the many elements of uncertainty involved, it perhaps is unnecessary to speculate further upon the bearing of this supply on the problem under discussion.

In the neighborhood of some of the canneries to-day, where the waste from the dressed salmon is thrown into the water, there are seemingly hordes of dogfish. These could be taken with the utmost ease and would make an abundant source of material on which to operate a fertilizer plant. It must be borne in mind, however, that when the food supply which now attracts them to the canneries is cut off, as it would be if a by-products plant were instituted in connection with the cannery, they would cease to congregate there in such numbers. Also, if attacked by any of the present methods of

fishing with hook and line or seines, it is possible that they would desert the waters where so attacked.

In past years it has been true that in the height of the fishing season, when the salmon were most abundant, large numbers were thrown away. The reasons for this lay in the fact that more salmon were caught and delivered at the canneries than could be preserved. With the fish delivered, it remained only to do what the circumstances showed was the logical thing—to discard the less valuable part of the excess delivery and preserve the more valuable. The error, of course, lay in permitting the delivery of such large quantities of fish. Once this error was committed the resulting waste was unavoidable. Even to-day, with the increased demand for fish and greater facilities for communication, there occasionally occurs a similar waste. During the summer of 1913 the civic authorities of Anacortes, Wash., were called upon to take action to protect the city from the nuisance resulting from the dumping of "many thousand" of salmon into the harbor.[1]

Such an oversupply of fish at a cannery is liable to occur at any time during the period of greatest abundance of fish as long as the present methods of securing the fish are employed. In localities where there are several canneries in operation it is frequently possible to sell the surplus taken by one cannery to supply the needs of another. But where all the canneries are pursuing the fish with equal success, it is evident that a superfluity for which there is no demand is likely to occur.

It is most desirable that these fish be allowed to remain at liberty and to continue on their way to the spawning grounds. But once taken and allowed to die, any use whatever is preferable to throwing them back into the water to cause pollution and create a nuisance. In case of a by-products plant being in operation as an adjunct to or in the neighborhood of a cannery, the logical thing would be to render for fertilizer and oil the oversupply of salmon. A law which would permit the capture by the packers of more fish than could be used for food, if at all reasonable, would permit their use in this manner.

A circumstance which would militate against this incidental supply of raw material being of probable value to a by-products plant is the fact that it would be available only while the cannery is being operated at maximum capacity and, on rare occasions, when, through some mishap, the operation of the cannery temporarily is suspended. The capacity of a by-products plant quite possibly would be such as to enable it to treat only the maximum output in waste of the cannery or canneries, and in that case it would not be able readily to

[1] The American-Reveille, Bellingham, Wash., Sept. 2, 1913.

adapt itself to such a sudden increment in the amount of material to be handled.

A practice formerly much in vogue and still used to a small extent is that of curing what is known as "salmon bellies." The thin ventral walls of the fish are cut out, with a single stroke of a knife, and are packed in salt. They are considered a great delicacy. The remainder of the salmon, consisting of the greater part of the muscular portion, is thrown away. To what extent this practice prevails it is impossible to say, as the "salmon bellies" at times are prepared by members of the fishing gangs, ostensibly for their own use, while on the way from the fishing grounds to the canneries, the refuse being thrown overboard. In case of the institution of by-product plants in connection with canneries, the waste produced from this source should be investigated with a view to its utilization. Only when some use is made of the discarded greater portion of the fish can this extremely wasteful practice be justified.

In addition to the "salmon bellies" prepared by those associated with the fishing industries for their own consumption, 1,118 barrels are reported as prepared for the market—468 barrels in Alaska and 650 in the State of Washington. In some cases the residual salmon is salted also; to what extent can not be determined from the statistics available. It is probable that the portion preserved as the "belly" is about 10 per cent of the whole salmon. The residue from the preparation of 1,118 barrels of 200 pounds each would amount to about 1,000 tons.

In the dressing or "butchering" of the fish the first operation is the severing of the head. This is true whether the dressing is done by hand or by machine. If by hand the head is severed by the first of two "butchers" working together, the second of whom opens the fish and removes the viscera. If by machine, as has been described, as the fish enters the machine it is lifted against a knife which severs the head. In either case the head is cut off as a separate operation. This circumstance makes it a simple matter to collect the heads separately from the other waste.

The balance of the waste is produced together, whether coming from the knives of the human operator or the machine. It consists of the roe, the entrails and other viscera, and the fins and tails. With the fins are cut off portions of the flesh, and with the tail at least 2 inches of the fleshy portion of the fish is severed. The stomach and entrails make up only a small portion of this material. Certain species of the salmon after they start on their course toward the spawning grounds, or certainly after they reach fresh or brackish water, it is said, take no food whatever. The alimentary tract of the fish caught near the shore is small and shriveled and quite empty. The energies required by the subsequent activities of the fish and the ele-

ments necessary for the further development and ripening of the roe are supplied through the metamorphosis of the materials already stored up within the body of the fish. The weight of the roe probably about equals that of the other waste produced with it; and that of the roe, fins, and tail, combined, probably equals that of the head. The roe, then, according to this estimate, makes up about 25 per cent of the weight of the waste produced in the cannery; and the head, according to the same estimate, about 50 per cent. Therefore about one-half of the materials designed for hypothetical rendering plants would be in the form of compact lumps, rather clean in nature, and easily handled (the heads). In this connection it may be said that during seasons of abundant materials some of the rendering plants now in operation make a practice, so far as possible without complicating the methods, of collecting only the heads. As the material is being loaded upon the scow for transportation to the rendering plant, streams of water are allowed to play over it until most of the finer matter is washed out and practically only the heads remain. This practice is followed because of the greater facility with which the heads can be rendered. The roe contains more gelatinous material, which adds to the difficulties of pressing.

An additional though small amount of waste is found in the water from the "slimers'" tables. This consists of the small strings of the viscera and of pieces of fins still adhering to the fish after having passed through the mechanical cleaner, and of the clots of blood which lie along the dorsal portion of the body cavity.

The entire mass of waste, with the exception of the heads, is moved by streams of water. Any system of collecting it entirely must depend on handling—to begin with, at least—the entire volume of water. It is a happy circumstance that all of this material has a higher specific gravity than has water, so that a complete separation of it from the water is possible simply through settling. This applies to every part of the waste, except, of course, the dissolved blood. The dilution of this solution makes its treatment for the recovery of the blood of doubtful economy. Since the final elimination of this large volume of water is so easy, no particular advantage is to be gained from the reduction of its volume so long as that reduction involves the loss of valuable solids. For that reason it probably would prove most advantageous to include the entire volume of water used in the various cleaning operations in any process for the collection of the by-products. In other words, since the separation of the solids from the liquids is so easily accomplished by simply permitting the former to settle out, but very little more expense would be involved in using a large than a small volume.

The physical composition of the waste produced in the cleaning house, then, is the heads, forming large lumps, the tails in smaller

lumps, together with a more or less finely divided and slimy mass of roe, pieces of flesh, and viscera. In rendering, the fleshy and bony portions withstand cooking with less tendency to disintegrate, as they are composed largely of muscular tissue on a framework of bone and cartilage. The roe, the milt, and the viscera are of much softer structure and are readily disintegrated. If the roe has reached that stage of development where the individual eggs have attained the size of peas, each has an envelope which is hardened and toughened by cooking or drying, and the albumen constituting the major portion of the egg is readily coagulated by heat. Materials which retain their structures under the cooking action of steam are rendered easily, while those which, on the contrary, disintegrate into an amorphous mass present serious difficulties. The preponderance of heads and fleshy pieces in the waste from the salmon canneries is a very favorable circumstance.

The waste as it is removed from the cannery floor is fresh, with but slight odor, and is practically entirely free from foreign substances. As most of the canneries are located in regions of comparatively cool climate, there is not a very strong tendency for the waste to spoil. This is particularly true of Alaska. On Puget Sound periods of warm weather of sufficient duration and severity to induce rather rapid decomposition in the waste may be expected. Altogether, the material is remarkably clean and inoffensive. And in a by-products plant in which the waste is rendered as fast as produced, the odors arising therefrom should be no more undesirable than those already liberated from the salmon cooking in the cannery proper. This odor, the odor of steamed salmon, can not be considered objectionable from a sanitary point of view.

OTHER SALMON-PRESERVING INDUSTRIES.

The preservation of salmon in salt constitutes an industry of considerable extent, though it scarcely compares with the canning industry in importance. It results in the production of large amounts of waste, and deserves attention as a possible auxiliary source of raw materials, under favorable conditions, for a possible adjacent rendering plant. The extent to which this method of preserving is carried on at any one station is scarcely great enough to warrant the installation there of a by-products plant to render the waste.

In Alaska, during the past season, "mild-curing" (the preservation by the aid of a small amount of salt combined with cold storage) was prosecuted to the extent that 7,443 tierces, of 800 pounds each, were prepared.[1] The greater proportion of this was packed in southeast Alaska. In the States, 3,621 tierces were packed on Puget

[1] Bower and Fassett, Pacific Fisherman, 12, No. 1 (Special), 58 (1914).

Sound, 300 on the Washington coast other than Puget Sound, 5,746 on the Columbia River, 2,381 on the Oregon coast, 4,789 on the Sacramento River, and 550 on Monterey Bay.[1] The waste in "mild-curing" amounts to about 25 per cent, or 250 pounds per tierce. The total waste in the industry, then, is about 3,100 tons.

Of pickled or salted salmon, 37,841 barrels of 200 pounds each were prepared in Alaska. Most of this was packed in western Alaska. In the State of Washington an additional number of 4,610 barrels were packed. The waste from this branch of the salmon-packing industry, on the basis of 25 per cent, or 75 pounds per barrel, amounts to 1,587 tons.

CHEMICAL COMPOSITION OF THE RAW CANNERY WASTE.

Analyses of samples of the waste from humpback salmon were made by J. R. Lindemuth, of the Bureau of Soils. The material from which the samples were taken was collected from the floor of a cannery in Alaska; after the addition of formaldehyde, it was sealed in tin for shipment. While its preservation was not perfect, the changes which took place within it during transshipment are not considered great enough to have altered materially its ultimate chemical composition or to have lessened the value of the subsequent analysis. From this material three samples were prepared, one of heads, one of fins and tails in equal proportions, and one of roe and milt in equivalent proportions.

Moisture was determined by evaporating to dryness a definite weight in a steam bath at a temperature of 100° C. Nitrogen, oil, and phosphoric acid were determined in the dry samples by the usual methods of analysis. In the last column of the tables are given the figures representing the content in oil, in gallons per raw ton, of the different samples. This figure is arrived at by calculating to gallons from the percentage composition of the dry sample of each, the value 0.925 being taken to represent the specific gravity of the oil.

TABLE VI.—*Analyses of samples of the raw material produced as waste in the mechanical dressing of "humpback" salmon.*

[Material taken from the floor of the cannery of the Pure Food Fish Co., Ketchikan, Alaska, July, 1913.]

Character of sample.	Moisture.	Nitrogen.	Phosphoric acid.	Bone phosphate $Ca_3(PO_4)_2$	Oil.	Oil per ton.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Gallons.*
Roe and milt (50 per cent each)	68.7	3.68	1.08	2.35	3.18	8.24
Heads	63.2	2.65	1.54	3.36	13.70	35.51
Fins and tails	63.26	3.11	2.20	4.80	11.16	28.94
Average	64.6	3.02	1.59	3.46	10.43	27.05

[1] Salt Fish Statistics, ibid., 85 (1914).

TABLE VII.—*The results reported in Table VI, recalculated to the water-free basis.*

Character of sample.	Nitrogen.	Phosphoric acid.	Bone phosphate $Ca_3(PO_4)_2$	Oil.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Roe and milt	11.76	3.44	7.50	10.16
Heads	7.20	4.18	9.13	37.22
Fins and tails	8.46	5.98	13.06	30.37
Average	8.65	4.44	9.70	28.74

The value representing the average composition of cannery waste is arrived at by adding the figures for the percentage composition of the heads, taken twice, and of the roe and the fins and tails. The values for the heads are multiplied by two, because, as it will be remembered, the heads are estimated to make up 50 per cent of the waste; while the roe and the fins, with the tails, are estimated to constitute 25 per cent each.

From this table it appears that the heads are richer in oil than the other parts of the waste. This is to be expected, and agrees with the facts as established practically in the rendering plants operating on this material. The nitrogen content of the heads is correspondingly low. As it is the oil which constitutes the greatest value among the substances recovered, this fact makes the heads the most valuable part. The high nitrogen content of the roe is to be expected, as it is made up to such a large extent of albuminous compounds. Its low content in oil likewise conforms to one's preconceived ideas.

On the basis of the analysis reported in Table VI, the value of the raw cannery waste may be computed.

The percentage of nitrogen, 3.02, is equivalent to 3.67 per cent ammonia, NH_3. This, in the retail market, may be expected to bring $3.20 per unit (a unit being 1 per cent); bone phosphates is valued at 10 cents per unit; and oil at 30 cents per gallon. Then:

3.67 per cent NH_3, at $3.20 per unit	$11.74
3.46 per cent bone phosphate, at 10 cents per unit	0.34
27.05 gallons oil, at 30 cents per gallon	8.12
Total value per raw ton	20.20

By present methods the manufacturers of fertilizer and oil from this material expect to recover about $15 in values. Present methods, then, can be considered as only 75 per cent efficient. In further substantiation of this conclusion are the results published by Thomas.[1]

[1] A. M. Thomas, Waste in Salmon Canning Industry. Pacific Fisherman, 12, No. 2, 26 (1914).

The averages of all experiments show the following facts: Each ton of salmon offal treated produced 800 pounds of mixed oil and fertilizer. Of this amount 200 pounds was salmon oil and 600 pounds oil-free fertilizer. The average analysis of the fertilizer thus produced was—ammonia, 14.3 per cent; bone phosphate, 13 per cent.

Estimating the 200 pounds of oil as being 25 gallons, at a price of 32 cents, which seems a fair average, we have, then, for each ton of offal treated an oil value of $8, and, estimating the value of a unit of ammonia at $3.20 and bone phosphate at 10 cents per unit, we have a fertilizer value at—14.3 per cent ammonia, at $3.20, $45.76; 13 per cent bone phosphate, at 10 cents, $1.30; or a total value of $47.06 per ton.

Then, at 600 pounds of fertilizer of this quality to the short ton of offal treated, we have $47.06×0.3=$14.12, the fertilizer value of 1 ton of offal, which gives a total available value of 1 ton of offal as—fertilizer, $14.12; oil, $8; total value, $22.12.

METHODS OF DISPOSAL OF WASTE.

It already has been stated that the first waste incident to the salmon-canning industry consists of throwing overboard the fish unfit for food and food fish for which there is no demand taken incidentally with the salmon. It has also been pointed out that the second waste, considered in the order of the manipulation of the fish prior to canning, consists in the occasional discarding of scowloads of salmon for which there is no demand.

In the succeeding operation of dressing the fish the head is severed first. If severed mechanically it falls directly into a chute leading beneath the cannery floor; if by hand, it, together with the viscera, is washed into a chute by water flowing through a trough at the back of the "butchers'" table. Where the dressing is mechanical, the severing of the head and the removal of the viscera are performed as separate operations by the same machine. The head falls into a chute which directs it beneath the cannery floor. The viscera fall through an opening in the floor situated directly beneath the machine. As there is considerable spattering, the floor around the machine is liberally covered with the waste. After a consignment of fish has been cleaned, or at the end of the day's work, the material on the floor is washed into the opening beneath the machine, or through the cracks, purposely large, in the floor. That produced by the operations of the "slimers" likewise is conducted beneath the cannery floor. From this point, all of the waste, whatever its source, is treated together or similarly.

In southeastern Alaska the common practice is to permit all the waste to fall into the water beneath the cannery. As it is heavier than water it sinks to the bottom. In certain instances it is exposed at low tide (see Pl. V), though generally the water is of sufficient depth to cover it. In certain localities it is devoured by dogfish as fast as produced, while at other canneries a few

miles distant these scavengers are strangely missing. In some cases the tidal currents carry the waste away, while in others, again, it accumulates on the bottom throughout the season. In such instances fermentation takes place slowly, with the production of obnoxious gases, which may be liberated slowly or may be held within the mass and released in large volumes and with considerable force. In a few instances in Alaska the waste enters chutes beneath the cannery floor, which conduct it to deep water at a distance from the cannery.

This practice has very serious objections. Practically always the waters around the canneries become fouled through the putrefaction of this waste in the water. Even though it may fall upon the bottom beneath the low-water mark, putrefaction within it will cause it to rise to the surface and some of it will find its way to the beach beneath and close to the cannery buildings. The amount may be small, but it will be sufficiently great to taint the air with its odor and convey the impression of an insanitary cannery. The pollution of the waters of the neighborhood likewise most probably results in those waters being deserted by fish which do not feed upon the putrefying refuse. This has been pretty thoroughly established in other regions in the case of certain food fishes. It is safe to assume that other fish possess some of the same fastidiousness. This may appear to be a matter of slight moment; but there are those who believe, and whose belief seems entirely justified by the known facts, that the disappearance of the salmon from certain waters of the East where they once swarmed in great numbers has been caused by the pollution of those waters. To be sure, this is a belief and not a demonstrated fact, but to disregard it and the warning which it gives is to run a risk that the fishing industry can ill afford to take. Likewise, where the cannery is located close to a town the nuisance created by the polluted waters results in a feeling of antagonism on the part of the residents of such a settlement. To retain the sympathy of the residents of a neighborhood in which an industry is located is being recognized as a matter of importance. There is in Alaska already a lack of sympathy with the packers on the part of the residents, who show an inclination to regard them as being indifferent to the well-being of Alaska and Alaskans. It is even claimed that this feeling has found expression in recent legislative enactments.

In certain parts of the Bristol Bay region the lack of deep water near the cannery makes it necessary to carry the cannery waste away from the vicinity of the cannery. This is done by loading the waste upon scows and towing them out to deep water for emptying. The same practice is resorted to in certain regions on Puget Sound, where the nearness of towns makes the pollution of the waters of the harbor

in this manner prohibitive. This method of disposal involves serious expense both in the construction and maintenance of scows and special loading devices and in the actual expense of towage, in addition to which is the inconvenience of applying the cannery tugs to such work during the height of the fishing season.

AMOUNT OF WASTE UTILIZED IN THE VARIOUS CENTERS.

COLUMBIA RIVER.

Of the 4,000 tons of cannery waste produced in the canneries of the Columbia River in 1913, only 800 tons were utilized for the manufacture of fertilizer and oil, leaving a balance of 3,200 tons which was thrown away. This amount was rendered in one fertilizer and oil plant situated near Astoria, Oreg. The raw materials for this plant were secured exclusively from the canneries of Astoria, a maximum haul of 7 miles. Its output in finished products during the season of 1913 was about 80 tons of dry fish scrap and 20,000 gallons of oil.

PUGET SOUND.

During the season of 1913 approximately 15,500 tons of raw cannery waste were treated in the fish-rendering plants of Puget Sound, with the production of 1,550 tons of dry scrap and 273,000 gallons of oil.[1] Four plants were in regular operation, one being situated at Seattle, two at Anacortes, and one on Lummi Island, opposite Bellingham. A fifth plant, of large capacity, situated on Eliza Island, near Bellingham, was undergoing its initial trial during the summer, but marketed no output. Of these plants, the four situated near the Bellingham-Anacortes center of the canning industry naturally obtained the bulk of their raw materials from the canneries of the immediate neighborhood.

ALASKA.

At present there is but one rendering plant operating on salmon waste in the entire territory. This is strictly a by-products plant as an adjunct to a cannery, and is designed for a capacity limited to the maximum output in waste of the cannery of which it forms a part. The equipment was installed just prior to the fishing season of 1913. Preliminary runs showed that the capacity of the drier was insufficient to dry the output of the digesters or to permit the plant to run at an economical rate. For that reason it was not operated throughout the season. It was operated long enough, however, to show that the process employed yielded a good quality of oil and dry scrap of entirely satisfactory composition and appearance.[2]

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[1] Pacific Fisherman, 12, No. 1 (Special), 1914.

[2] The analysis of this product is reported in Table VIII, on p. 33.

FISH SCRAP FROM SALMON WASTE.

From preceding paragraphs it is to be seen that during the last year a total of 1,630 tons of dried fish scrap and 286,000 gallons of oil were manufactured from the waste from salmon canneries on the Pacific coast of the United States. The amount of these products represents the output of five plants.

The methods employed in at least four of the five plants in all essentials are similar. The differences between them are chiefly in mechanical features and in the arrangement of the machinery within the plants. The same process is used in all of them. This consists in cooking the waste by steam, either in closed retorts under pressure or in open retorts, in pressing the cooked fish in one type of press to remove the water and oil, and drying the scrap. In the following paragraphs the methods in vogue in these rendering stations are described in some detail.

COLLECTING.

The waste is carried from the cannery to the rendering plant on scows. In cases where the floor of the cannery is high enough above the surface of the water the refuse from the various "butchering" operations can be run through chutes into the scows by gravity. There are instances, however, where this is not possible at high water, and it has been found necessary to install conveyors for loading the scows. These are arranged beneath the cannery floor. The material is delivered to them at the bottom of hopper-shaped receptacles which receive the waste from the cannery floor. Where the top of the scow at high tide is above the level of the cannery floor, two conveyors working together at an angle to each other are utilized, one bringing the material horizontally to the edge of the dock to which the scow is made fast and the other lifting it over the side of the scow. The conveyors may be operated by a small gasoline engine or by the same motive power that operates the mechanical cleaner or the cutter.

UNLOADING.

The charged scow is towed to the dock of the rendering plant, where it is unloaded mechanically. An adjustable bucket conveyor, of the wheat-elevator type, is rigged in such a manner that its free end can be thrust into the mass of material constituting the load of the scow. The load is thus lifted and deposited directly, or by means of an auxiliary conveyor, into storage bins. From these it is drawn off as desired into cooking vats. What is regarded as the best practice consists in raising the waste directly to bins situated over the cooking vats, which in turn are placed over the presses, so that only one lifting is necessary, and the material thereafter may pursue its course through the factory by gravity.

COOKING.

The upright, cylindrical retort is in general use. It is provided with openings in top and bottom for charging and discharging, respectively. If the fish is to be cooked under pressure the opening in the top is generally smaller than otherwise, so that it more readily may be closed and rendered tight enough to retain the steam at the pressure at which it is admitted to the retort.

The manner in which the steam is admitted and the length of time during which the charge in the retort is subjected to the cooking action of the steam vary from plant to plant. In certain instances the steam is injected at the bottom and allowed to permeate the mass of waste undergoing cooking. When it appears at and issues freely from the top the charge is deemed sufficiently cooked. In other cases the cooking is continued for 12 hours under a pressure of 20 pounds of steam. As each operator regards his methods as the best, it may be said that all of the methods give equal satisfaction.

After cooking, the charge may be allowed to stand to settle, or it may be drawn off at once into the presses. If the former procedure is observed, much of the oil released in the cooking rises to the surface and is drawn off in any suitable manner. In any case the charge is admitted to the presses hot. As a result of the cooking the material may be thoroughly disintegrated to form a thin soup, or it may be broken up into coarse particles. The only essential seems to be the disintegration of the heads.

What is considered a good practice is to run the charge as soon as sufficiently cooked from the retorts into a storage vat or "slush box." This is provided with steam coils so that the material may be kept hot. From this vat the cooked fish is admitted to the presses. This system admits of greater elasticity, making the rate of cooking independent of that of pressing.

PRESSING.

Presses of the hydraulic or the "knuckle" type are in general use. Owing to the fine state of subdivision of the material to be filtered, the part of the press functioning as a filter must have very fine apertures in order that the separation between liquids and solids may be effected. The readiness with which such fine material closes the apertures of a filter and retards separation necessitates a very large filtering surface for a comparatively small amount of material. These conditions are fulfilled in the salmon-waste filter presses by the use of a heavy and compactly woven sort of burlap bagging ("hop cloth"), in which only small portions of the waste are put to be pressed.

The charge for the presses is made up in the following manner: A framework of 1-inch strips of wood inclosing a square of about 3 or 4 feet is placed on a truck and over it is thrown a square of the

burlap. This makes a shallow receptacle, which is filled to the depth, perhaps, of about 3 inches with the material to be pressed. Then the loose edges of the burlap are folded over on top of the material so that it is entirely covered. On top of this is placed a square, of about the same dimensions, of wooden slats, held together by a suitable framework. On the slats is placed a second frame and a second square of burlap, which receives in like manner another charge of material. This operation is repeated until a stack of batches of material held thus in sections of burlap is built up of sufficient height to fill the press. Sheet-iron plates may be substituted for the wooden slats.

In charging, the truck which is to support the charge is wheeled beneath the cookers or the "slush box." For this purpose a track is built from the press to the cookers. The cooked fish, by the manipulation of cocks and a movable spout, is permitted to flow upon the receptacle arranged for it. When the charge has been completed the truck with its burden is wheeled into the press. The pressure is applied until the maximum power of the press has been reached, or until no further amount of water and oil can be removed.

It is desirable that the material be pressed while still hot, as the water expressed contains glue in solution which on cooling tends to harden and clog up the filter.

When removed from the press the solids have been forced into hard cakes about an inch in thickness. These are shaken out of their burlap envelopes onto the floor, when they are ready for the driers.

The oil and water expressed from the scrap are permitted to run together to receiving vats. On standing and with the aid of heat, the oil rises to the surface and the fine sludge which has escaped the filter settles out. The oil is drawn off from the surface into a series of vats, where it is subjected to successive simple treatments for its purification. Suspended solids and occluded liquids are washed from it by bubbling steam through it, and occasionally it is "cut" with sulphuric acid to effect a clarification.

The residue pressed from the cooked fish may be saved to recover the glue which it contains, or it may be allowed to go to waste. The latter practice is the one generally adopted. For the preparation of glue it is thoroughly freed from solid matter and is then evaporated by steam coils to the desired concentration.

DRYING.

Of the several types of driers in use on the Pacific coast, there is only one employed in drying fish scrap from cannery waste which is at all comparable to the hot-air driers found in common use on the Atlantic coast. This is a drier of large size and capacity, the operation of which involves the principle of both direct and indirect heating. It is a rotary cylinder of iron mounted inside of an inclosing

chamber of brickwork. Hot gases from crude petroleum burners are admitted to the chamber surrounding the cylinder and are drawn thence into the cylinder through apertures constructed at intervals in the walls. The scrap to be dried is admitted at the hot end of the cylinder and removed at the cool end, thus traveling with the current of air. From the cylinder it drops into an elevator and is carried therein directly to the bagging room. The current of gases through the drier is maintained by a rotary fan situated behind the drier. By means of this the gases drawn from the drier are forced through a chamber where they are washed free from suspended particles by means of a water spray. Thence they are driven through the fire box beneath the factory boilers. In this manner odors arising from the hot-air drier, and constituting, perhaps, the only objection to its use, are completely destroyed.

In the fertilizer plants of the Pacific coast the steam drier is employed most commonly, owing possibly to the simplicity of its installation and operation and to the fact that of all the driers it is most readily available in the desired capacities. It is not intended that the idea shall be conveyed by this statement that the steam drier inherently is more simply installed and operated. Such is not believed to be the case. But at present the hot-air driers advertised for sale and actually in use are large in both size and capacity and are unfit for the treatment of small amounts of material. The manufacturers have failed to meet, or perhaps to create, a demand for driers of small capacity, and for that reason the steam drier is in most common use. An additional advantage possessed by the steam drier is its simplicity of regulation. Overheating being impossible, it remains only to admit the steam and wait for the charge to dry. It can not be regarded as the most efficient or as the most economical except in cases where exhaust steam is employed.

The type of steam drier found in use in drying scrap from salmon waste usually is a horizontal cylinder provided with steam coils inside, or encircled by a steam jacket. For stirring, the cylinder is equipped with paddles revolving in it, or the cylinder itself is rotated on a horizontal axis.

A third type of drier, recently installed in a certain manufactory, is unique in that it makes use of the waste heat from the fires beneath the factory boilers. As this drier was designed by the operator from ideas suggested by his experience, and is not advertised for sale by the manufacturers of driers, the writer does not feel justified in publishing here the details of its construction. It should suffice to say that the drier is reported as being quite efficient and satisfactory, and the scrap coming from it is of a very high quality. Its lack of importance as a type is more than made up by its value as an illustration of what is possible in the enhancement of economy in a fish-rendering plant.

THE PRODUCTS.

CHARACTER OF SCRAP.

The scrap produced from salmon waste is of very high quality. For its value as fertilizer, it is open to criticism only on the score of its high content in oil. This amount of oil probably is not sufficient to prove a serious detriment to the soil nor, possibly, materially to retard the decomposition of the scrap within the soil. But it is disadvantageous in that it is so much inert material of no fertilizer value. The fact that the oil, of high value if extracted, here plays the rôle of a worthless diluent of a less valuable product, has no bearing on the value of the scrap as a fertilizer; instead, it concerns only the economy of the process by which the material is prepared. With regard to the bearing of the presence of oil in fertilizer materials on the value of those materials, attention should be called to the work of Skinner and Beattie,[1] of the Bureau of Soils, having to do with the value of city street sweepings for fertilizer purposes. To explain the poor manurial value of this material it was supposed that the presence therein of oil, dropped upon the streets by automobiles, prevented its decomposition, a supposition which became a conclusion when it was demonstrated that the same material, after treatment to remove the oils, showed a greatly enhanced manurial value. This oil is largely, if not entirely, mineral oil, which it is commonly known is much less readily decomposed than animal oils, such as fish oil. In this connection a comparison of the fertilizer values of oily and oilless fish scrap would be of distinct interest.[2]

CHEMICAL COMPOSITION OF SCRAP.

Samples of salmon scrap representative of the product of the various manufacturers were received at the laboratory in canvas sample sacks. These samples were ground to a powder that would pass a sieve of 16 apertures per linear inch. Samples of 2 grams each were then dried for about 5 hours in a vacuum drying oven at a temperature ranging between 75° and 85° C. The loss in weight was recorded as moisture. The same samples were then used for the determination of oil, which was extracted in a Knorr apparatus with ether. Great difficulty was experienced in removing all the moisture without the loss of oil. Nitrogen was determined by Mr. T. C. Trescott, of the Bureau of Chemistry, by the official method. For the determination of phosphoric acid the official gravimetric method was used. In Table VIII are reported the results of analyses of five samples of salmon scrap from an equal number of manufactories.

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[1] Circular 66, Bureau of Soils, U. S. Dept. Agr.

[2] Experiments recently made in these laboratories by Skinner and Lindemuth, in which the fertilizing value of oily and oilless fish scrap was compared, showed that the latter (extracted with ether) give pronouncedly better results than the former.

TABLE VIII.—*Analyses of fish scrap prepared from salmon cuttings.*

Number of sample.	Location of factory.	Description.	Nitrogen.	Phosphoric acid (P_2O_5).	Moisture.	Oils.[1]
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	Klawack, Alaska	North Pacific Fishing & Trading Co. Sample from trial run with steam drier.	9.39	5.32	5.36	14.96
2	Anacortes, Wash.	Robinson Fisheries Co. Dry scrap from steam drier.	8.26	7.91	5.21	17.36
3	do.	Russia Cement Co. Dry scrap from hot-air drier.	9.49	9.26	5.26	8.32
4	Seattle, Wash.	Brandel Chemical Co. Dry scrap from steam drier.	8.76	7.00	3.91	20.02
5	Astoria, Oreg.	DeForce Oil Works. Dry scrap from hot-air drier.	7.63	12.08	5.11	10.96

[1] More accurately, ether extract. This consists principally of oils.

COMPARISON WITH MENHADEN SCRAP.

For the sake of comparison between the salmon and menhaden scrap, the following table of analyses, made by E. G. Parker and J. R. Lindemuth, of the Bureau of Soils, is introduced here. This has been compiled from analyses made during 1912–13, and has been published in a former report.[1]

TABLE IX.—*Analyses of fish fertilizer prepared from menhaden scrap.*

Number of sample.	Location.	Description.	Nitrogen.	Phosphoric acid (P_2O_5).	Moisture.	Oils.
			Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1	Kilmarnock Va.	From Eubanks Tankard Co. Dry scrap (from 6 sacks).	8.93	6.17	6.48	5.91
2	Taft, Va.	From Taft Fish Co. Dry scrap (sample of 525 tons).	8.96	7.75	6.18	6.81
3	Irvington, Va.	From Carters Creek Fish Guano Co. Dry scrap, dried in hot-air and steam driers (from 1 sack). Fall product.	7.70	5.22	11.68	6.62
4	Cape Charles, Va.	From Atlantic Fish & Oil Co. Dry scrap, ground (from 3 sacks).	9.29	6.12	7.86	5.38
5	do.	From Dennis Fish & Oil Co. Dust from grinders.	8.80	5.21	7.17	7.55
6	Beaufort, N. C.	From Beaufort Fish-scrap & Oil Co. Dry scrap, hydraulic presses. Sample from heap.	8.22	5.95	6.13	8.57
7	Morehead City, N. C.	From R. W. Taylor. Dry scrap from open heap.	8.49	5.95	9.12	8.23
8	do.	From Chas. S. Wallace. Scrap, dry, from hydraulic presses.	7.76	9.65	8.15	7.56
9	Lenoxville, N. C.	From C. P. Dey. Ground scrap, sun-dried, from hydraulic presses. Sample from heap.	7.81	5.85	7.46	7.89
10	do.	From C. P. Dey. Scrap, dry, ground, hydraulic presses. Sample from heap.	8.29	9.00	7.00	5.40
	Average		8.43	6.69	7.72	6.99

[1] Bul. 2, U. S. Dept. of Agr., The Menhaden Fish Fertilizer Industry of the Atlantic Coast.

The salmon scrap has a lighter color and more pleasant odor than the menhaden scrap. This, again, possibly does not concern its fertilizing value, though there is a remote possibility that it may affect its demand in the trade. It is said that some agriculturists appraise the value of fertilizer materials by the disagreeableness and strength of their odor. On the contrary, it is a better established fact that considerable prejudice exists against fish scrap on the part of common carriers and the public in general because of its odor. Since nothing is to be lost and something is to be gained by reducing the disagreeable odors of fish fertilizer, the point mentioned is favorable to the salmon scrap. The better smell of the latter is due most probably in greatest measure to the fact that it is dried at moderate temperatures and is not scorched, as inevitably must happen in the hot-air driers as now operated on the Atlantic coast. It also is true that the menhaden scrap is dried in a stream of hot gases generated in a soft-coal fire; the soot from this doubtless contributes likewise to the dark color of the product.

Another point of difference between the salmon and menhaden scrap is introduced by the occasional acidulation of the latter. The addition of sulphuric acid to the scrap is practiced most generally to disinfect the undried but freshly cooked and warm "pomace," and to render it unfit as a breeding place for flies. This is resorted to, as a rule, only when the scrap is being produced at a rate greater than that at which it can be dried. The acidulation frequently is followed by drying. The addition of sulphuric acid to the scrap is supposed to be beneficial in that it "fixes the ammonia" and renders soluble the phosphoric acid of the calcium phosphate constituting the bones. While it induces a disintegration and pulverization of the scrap, and enables the producer to sell the bone phosphate present as soluble phosphoric acid, at the same time it acts as a diluent of slight, if any, fertilizer value, with no rating on a fertilizer basis.

In the foregoing comparison of scrap from salmon and menhaden, respectively, it is not intended to convey the idea that the menhaden scrap for fertilizer purposes is inferior to that from the salmon. It is believed that the ammonia and phosphate of the one is as valuable as that of the other.

FISH SCRAP AS CATTLE AND POULTRY FEED.

To discuss fish scrap from any point of view other than that of fertilizer, perhaps, is beyond the province of this report. It should be pointed out here, however, that with such fertilizer materials as dried blood, abattoir tankage of high grade, cottonseed meal, and fish scrap, it is better agricultural practice to feed these to stock, provided, of course, that all barnyard manures be conserved care-

fully, than to apply them direct to the soil. It can be taken as thoroughly well established that both the nitrogen and the phosphoric acid, after performing their rôle in the life processes of the adult animal, are eliminated. Then the high food value of these rich foods is utilized, and at the same time the fertilizing elements are still available for use on the growing crops. From the point of view of cattle and poultry feed, the salmon scrap must be considered superior to the menhaden. In the first place, the acidulated scrap is totally unfit for feeding purposes. Its use in that manner undoubtedly would result in disaster. And in smaller degree, the greater care expended in drying the salmon scrap makes it a more desirable article of food. In fact, when the nature of the raw material and the sanitary condition under which it is treated, obtaining in certain manufactories, are considered, it might almost be regarded as fit for man's consumption. It would be interesting to learn whether the oil remaining in the salmon scrap is of a more digestible nature than that in the menhaden scrap. No experimental data is at hand in substantiation of such belief; but such appears plausible when it is recalled that the salmon oil is light and sweet and partakes more nearly of the nature of the edible oils, while that from menhaden is dark, heavy, and viscous and has a disagreeable odor.

The subject of the suitability of fish scrap for cattle and poultry feed and the experiments performed relating thereto have been discussed in an earlier publication of this department and therefore will not be repeated here. In all of the experiments, records of which have come to the attention of the writer, the results have been affirmative and of such a nature as to justify the further exploitation of this food material for that purpose. The reader interested in this phase of the subject is referred to Bulletin 2, United States Department of Agriculture, The Menhaden Fish Fertilizer Industry of the Atlantic Coast.

OIL.

The literature contains little having to do with salmon oil. The amount actually produced, 286,000 gallons, is too small to give it any great importance in the industries. It is rated, however, as a high-grade fish oil. The price which it brings in the market, 30 cents a gallon, against 23 cents for menhaden oil, is sufficient evidence of that fact. There is no reason to doubt that it is destined to play an important part as an animal oil when the salmon-scrap industry is fully developed and there is enough oil available to make its study and exploitation profitable.

In the absence of more detailed information concerning the physical and chemical properties of salmon oil, it must suffice to say that it is merely a high-grade fish oil. The crude salmon oil is lighter in color than, perhaps, the refined menhaden. Its properties, as now

understood, adapt it to the uses to which menhaden oil successfully has been applied, conspicuous among which is its utilization as a lubricant, and especially in the paint and enamel industries.[1]

GLUE.

Fish glue made from salmon is regarded as low grade and of proportionately slight value. In this particular it differs markedly from that prepared from cod skins. It is used with success in the preparation of sizings and allied materials.

METHODS PROPOSED FOR THE TREATMENT OF SALMON CANNERY WASTE ON A LARGE SCALE.

In the treatment of salmon cannery waste two methods immediately suggest themselves: (1) Treatment in large units, and (2) in small units. The former at first glance appears the more desirable, as it generally is understood that large-scale manufacturing operations are more economical in both labor and equipment than those conducted on a small scale. And it is the large-unit plan that now is in operation; without exception, all the salmon scrap at present produced is the product of the large-unit plants. The foregoing description, then, of the present method employed in rendering salmon waste applies in a large measure to that of a proposed central rendering plant. In fact, it may be argued that it is not wise to diverge from the methods now in vogue as they are the only ones which have been applied with any commercial success whatever.

THE CENTRAL RENDERING STATION.

The failures in the operation of centrally located rendering plants have been as numerous as and far more conspicuous than the successes. The causes operating to bring about these failures, it appears at this distance, were manyfold. Speaking of the failures collectively and not as individuals, it is evident that over capitalization and extravagance in expenditure for equipment, the failure of equipment to yield its expected performance, errors in the location of the plant, and general inexperience all contributed.

The plan has inherent faults. These are twofold: The high expense involved in hauling the raw material to the plant and the lack of machinery which would make the rendering process continuous, automatic, and economical. A further disadvantage, applying to both proposed methods but in greater degree perhaps to that of the central plant, is the shortness of the season during which the plant would be in operation. In this discussion the adoption of the plan is opposed further on the ground of its general failure to meet the demands of the problem.

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[1] For a brief discussion of menhaden oil see ibid., p. 46 et seq.

In considering the first objection it becomes evident that the larger the rendering plant the larger must be the equipment in tugs and scows and the longer the haul. The irregularity with which the canneries operate and the vagaries of the weather introduce elements of uncertainty which make it difficult to calculate the probable limits within which the waste profitably can be collected.

COLLECTING THE MATERIAL.

Loading the waste.—Three methods are available for loading the cannery waste: (1) By means of a scow under the dock at each cannery; (2) by means of a storage bin under the dock at each cannery; (3) by means of a storage bin on the dock at each cannery.

(1) The first method is objectionable in that the outlay for scows would be too great. Two would be required for each cannery, one receiving a load while the other was being unloaded. A scow 30 by 16 feet in dimensions would cost about $300. The investment in these would be $600 for each cannery tended. Smaller scows designed to hold the maximum daily output in waste of the cannery could be built, perhaps, for a smaller sum, but their usefulness for other purposes would be restricted.

A contract between a cannery and a central rendering station most probably would specify a daily removal of waste. Certainly there would be days when the yield in cuttings would be small, far too small to fill a scow. Yet under the contract and this system of collecting it would be necessary to remove the partially loaded scow and transport it to the rendering station, or else carry it away for emptying. And even if the daily collection were not required, in warm weather a frequent collection would be absolutely essential and easily might result in the enforced transportation of but partially filled scows.

The greatest advantage to accrue from this method would be that the waste could be sluiced directly from the cannery floor or cleaning tables into the scow and would be ready for transportation without any further handling whatever. On the other hand, an occasional cannery would be found to have been built too close to the surface of the water to admit of the loading of a scow in this manner.

In a foregoing paragraph has been described the method of loading, by a simple system of conveyors, when the cannery floor is too low to admit of the scow's being placed beneath. Where such an apparatus has to be installed and operated, the advantages of the direct loading into a scow disappear.

(2) Under ideal conditions the collection of the waste in storage bins placed beneath the cannery floor or dock is the most economical. The conditions considered ideal are that the cannery floor or dock shall be of such a height that the scow to be loaded can be placed

beneath the storage bins so that it can be done entirely by gravity. That it be loaded thus by gravity is a virtual necessity, as pitching the material from the bin into the scow by manual labor would be too expensive. But it not often is found to be possible to load the scow by gravity at high tides, and therein lies the chief objection to the method.

The bin so placed would be loaded by sluicing the cuttings directly into it. This would entail no extra labor over that of the present practice. The bin should be built with a bottom sloping toward an opening through which the waste could be admitted as desired into the scow. In the sides of the bin, sections of close-mesh wire netting could be inserted, if desired, to permit the excess water to drain away; or, since the cutings are heavy and will sink, the water could be permitted to run over the top edges of the bin. The latter is undesirable as entailing an extra and unnecessary weight on the bin.

An additional advantage of any system involving the use of storage bins is that, under favorable conditions, a large-capacity scow can make the circuit of the canneries tended, collecting what material has accumulated since the last round, whether that amount be large or small.

(3) Storage bins placed on the dock at each cannery would possess the advantage that they could be unloaded by gravity at any tide. The chief objection to them would be that they would have to be loaded mechanically. The waste would have to be brought from beneath the cannery floor, by conveyor, outward and upward, to the bins, involving the expense for installation and operation of the conveyors. As this is the method which, under the conditions usually obtaining, is the only one under absolute mechanical control and therefore the only reliable one, it perhaps is the most desirable method of the three. On the other hand, there is no reason why the method to be employed at each cannery can not be determined by the conditions peculiar to that cannery. No hard and fast rule need be applied.

Tugs.—The number of tugs required to collect the raw material from the various canneries would be determined by conditions such as the number of canneries tended, their output in waste, the system of collecting, the capacity of the scows employed, and especially the position of the canneries with respect to each other and the rendering station. In elaboration of the last-named condition it should be pointed out further that if the canneries were situated in such a way that the direct course from the farthest one to the station lay past the others, one tug and scow or scows of sufficient capacity could collect the load from a number of canneries on one trip.

RENDERING APPARATUS.

The equipment and operation of the large-scale rendering stations now in successful operation have been described compositely in foregoing paragraphs. A strictly conservative procedure would be to adhere to demonstrated methods. However, since these methods once were in universal use on the Atlantic coast and now have been discarded almost universally to make way for new methods, a discussion of new methods, and even a recommendation of their cautious adoption may be justified.

The only process which has been applied with any success to the rendering of this class of material on the Pacific coast, it has been shown, is discontinuous. The apparatus required by this process may be installed and operated in small units, necessitating a multiplication of the labor involved, or in large units, involving more labor than the small units, of course, but not proportionately. Since the material to be treated is secured in irregular and uncertain amounts, a number of small units would afford more of the required elasticity than an equivalent number of large units, but the cost of labor required to operate such a number of small units soon would become prohibitive. So, by nature, this apparatus offers serious objections to its adoption in the large-capacity plants.

The continuous and automatic machines for cooking, pressing, and drying in use in the fish-rendering industry of the Atlantic coast should lend themselves readily to adaptation to that industry on the Pacific coast. These make possible the cooking, pressing, drying, and intermediate handling of the fish entirely by machinery, with a high efficiency and minimum expenditure of labor. The unloading is done by elevators, which deposit the fish in storage bins, from which they are fed into continuous steam cookers, long tubular chambers through which the fish are moved by a rotating screw, being played upon by jets of steam. Thence they are transported by conveyors, into which they are fed, to the power presses. These are steel-slatted cones, through which the cooked fish are forced by a rotating screw. As they move toward, and before they can pass out of, the small end of the cone, they are squeezed into a very small compass. This pressure rids them of the greater portion of their water and oil. From the press they are conveyed, again entirely automatically, into a direct-heat, rotary, hot-air drier.

A plant designed for the treatment of 100 tons of cannery waste per day and equipped with the automatic machinery complete would cost about $35,000. This estimate[1] is based on the following items.

[1] The itemized statement of the cost of equipment and plant is made possible through the courtesy of Mr. Philip Renneburg and Mr. P. Burgess, of Baltimore, Md.

Two 66 inches by 16 feet, 100-pound pressure, return tubular brick set boilers, 100 horsepower each, complete with independent stacks of No. 10 metal, with castings and fittings arranged for full flush front setting	$1,650
One 20-horsepower vertical engine, complete with all fittings (for elevator)	230
One 9 by 12, 20-horsepower, horizontal center-crank engine, complete with all fittings (for raw box transmission)	275
One 10 by 12, 25-horsepower, horizontal center-crank engine, complete with all fittings (for cooker and near-by transmission)	315
One 11 by 13, 35-horsepower, horizontal center-crank engine, complete with all fittings (to operate press)	355
One 10 by 12, 25-horsepower, horizontal center-crank engine, complete with all fittings (for drier and surrounding transmission)	315
One 150-light, 16-candlepower, vertical, electric-light engine, cased in, directly connected automatic lubricator and generator, with switchboard	725
One marine leg fish elevator, with measuring machine and all necessary transmission complete for elevating fish from scow to factory	1,650
Complete raw box transmission, consisting of all chains, attachments, buckets, sprockets, gears, shafts, and clutches, complete	1,500
One 17 inches diameter by 40 feet long, spiral worm steam cooker, complete, with driving sprockets	1,200
One 12-foot, all-steel, continuous screw press	3,500
One 5 feet 6 inches diameter by 40 feet long, two-bearing drier, with hopper, castings, blower fan, blower piping, and Jones underfeed stoker	2,500
Balance of and completing factory transmission, including pipe work in connection with boilers, engines, and pumps	2,500
One 1,200-barrel steel-plate, oil-storage tank	1,000
Incidentals, such as boiler feed pump, oil pump for transmitting oil to tanks, general wash-down pump, fish and coal measuring tubs, perforated piping system in connection with oil tanks, etc	1,500
Total	19,215

In addition to this, there will be an outlay for buildings, brickwork for the drier, and all foundations for buildings, boilers, engines, machines, and tanks. This cost is difficult to estimate, as it will be determined largely by local conditions and the factory site, but probably will approximate that for the equipment, bringing the total for plant and equipment to the figure mentioned above. In addition to this cost again would be added the items expended for tugs and scows.

Superficially there seems to be no reason whatever why the automatic and continuous cooker in its present form should not be entirely applicable to salmon cuttings. The rate at which the material is passed through, and therefore the length of time during which it is being subjected to the cooking action of the steam, are regulated with ease. Thus the degree of cooking is under complete control. It has been demonstrated that cooking under pressure is

not essential. However, even with the continuous cooker a certain degree of pressure can be maintained, if desired, by the correct modification of the cooker.

The press in use in the menhaden factories has been designed for expressing the cooked menhaden. As that material is markedly different from salmon waste, there is no reason to suppose that the press efficacious with the former will be so with the latter. However, there is every reason to believe that the press so useful with the one can be modified so that it can meet the demands of the other. This is not a necessary conclusion, since the limits of usefulness of this form of press may lie between the requirements of menhaden on the one hand and of salmon cuttings on the other. As indicated above, this is not believed to be the case. In this connection it should be emphasized that, in view of the fact that the screw press has never received a thorough demonstration in the salmon-scrap industry, before other plants are equipped with it it should be made to conform to the demands of that industry. This can be done only by thorough experimentation by those familiar with the press and the nature of the material to be pressed.

The rotary, direct-heat drier probably should be the most economical type at present available. Its present methods of operation can not be so considered. In construction, it is a sheet-iron cylinder, about 40 feet in length and 5 feet 6 inches in diameter. It is mounted, at a slight angle out of the horizontal, on roller bearings which support its weight and on which it revolves. The material to be dried is fed into the upper end and falls out at the lower. Also into the higher end is blown a stream of hot gases, generated by forcing air from a blower through the firebox of a furnace. The wet scrap falls directly into this stream of hot gases and by it is assisted through the drier. It also is lifted and let fall repeatedly by the rotation of the cylinder.

Such a drier yields about 45 tons of dry scrap per day. In practice the moisture content of the material (fish-pomace) is reduced from 55 or 60 per cent to 7 per cent, at a closely estimated cost of 50 cents per dry ton. This cost is based on the following items: To heat the drier, approximately 3½ tons of soft coal is required, while an additional 1½ tons is consumed in supplying the power for the rotation of the drier and the operation of the conveyors. One skilled laborer is required to operate the drier and two unskilled laborers to tend the drier furnace and the boilers.

For the most efficient utilization of a stream of drying gases, theory demands that it shall flow from the opposite direction over and through the stream of material being dried. Thus the hottest and driest gases are brought into contact with the hottest and driest part of the material being dried, and the coolest and wettest gases with the

coolest and wettest material. In this way the maximum moisture-absorbing capacity of the gases is made use of and their heat entirely is utilized. To make such a procedure possible, a lower initial temperature of the gases would be necessary to prevent the ignition of the hot, dry material; and it is probable that a longer drier and a more prolonged intermixture of the material and the drying agent would be necessary. A point might be reached where the energy necessary to rotate the drier for the increased length of time would cost more than the heat units conserved would justify. This is a matter which could be determined by experimentation.

In a drier of the above type use is made both of the heat units and of the drying action of a current of gas. The matter is entirely different from the evaporation of water in a closed vessel, where the evaporation of each unit weight or volume of water is accompanied by the absorption of a definite amount of heat. To be sure, all evaporation is so accompanied. But it is remembered that water is evaporated by a current of air without the application of artificial heat. And, too, the hotter and drier the stream of air the more rapid the evaporation. In the hot-air drier this combined action is made of use.

The fish-fertilizer industry as developed on the Atlantic coast has found the above-described continuous and automatic apparatus the most satisfactory for meeting the demands of that industry. On the basis of that verdict one is inclined to believe that this machinery most advantageously could be applied to the large-scale rendering of salmon-cannery waste, provided the proper modifications were introduced to make it entirely adapted to that sort of material. We do not regard the past failures of this machinery as significant of any fundamental unfitness, but rather of a lack of attention given the requirements of the new material to which it is applied. In the present stage of knowledge of the subject it appears that the continuous-process machinery conforms most nearly to the ideal equipment.

Rendering apparatus of various other forms are to be had. Many of these forms have been applied with success to the rendering of garbage and tankage. Some are designed with a view especially to the suppression of all disagreeable odors, others to the recovery of a larger percentage of the oils present. The latter usually involve the use of petrol or gasoline as the extracting agent, which effects a more complete recovery of the oils. This may obviate the necessity both of a press and a drier, the cooking, drying, and extracting being accomplished in one container, the retort. Theoretically, such processes for the recovery of oil are most nearly ideal. Whether they can be applied successfully to the rendering of fish, viewed from the commercial standpoint, remains to be demonstrated in this country.

OBJECTIONS TO THE CENTRAL RENDERING STATION.

SHORTNESS OF SEASON.

A serious difficulty in the way of making a commercial success of the central rendering station is the shortness of the season during which the plant would be in operation. This would be even shorter than that during which the canneries would be in operation, as both preceding and following the actual canning of fish there is a period when allied work is pursued. Furthermore, the rendering plant would have to be in readiness to handle whatever material the management had contracted for (certainly to be the entire output of waste of the cannery contracted with) whether it became available in large or small amounts. The result would be that for about nine months of the year the plant would be closed up; and for a considerable portion of the remaining three, while being held in readiness to operate, it still would be idle. This objection is entirely valid from the point of view of output, but not necessarily so from that of profit or investment. Money is invested in such enterprises, not because of their output in product, but because of the profits accruing. If the profits of the short season's operations represent an adequate interest on the investment, then the expenditures for plant are justified and objections on the score of shortness of operating season are eliminated. Aside from the inconvenience of reorganizing annually the corps of employees, the period of inactivity may be considered a benefit, as affording the management opportunity for other pursuit.

The inactivity of the plant during the operating season is a more serious obstacle to the success of the undertaking. There would be periods when no material was being delivered to the plant when it and its corps of laborers would be held in readiness for immediate operation. This would involve an expenditure of money for wages and of fuel for maintaining heat in the boilers from which there would be no returns.

A part of the equipment of such a rendering plant, the tugs and scows, it should be possible to keep employed profitably during the winter months. Whether this could be done would depend somewhat on the location of the plant and to a larger extent on the design of the tugs and scows.

In this connection it should be pointed out that the equipment provided for the treatment of cannery waste could be applied during several months of the year, when fish refuse is not available, to the treatment of kelp for the preparation of fertilizer. This topic is considered more fully in a subsequent chapter.

GENERAL FAILURE OF THE CENTRAL RENDERING STATION TO MEET THE DEMANDS OF THE PROBLEM.

Our problem being to devise a scheme whereby the valuable materials produced as waste in the canning of salmon in particular and the dressing of fish in general may be saved, any plan which provides for the conservation of only a portion of this must be rejected as inadequate. Therein lies a vital objection to the central rendering station idea—that at best it can render the waste only from those fish-cleaning establishments which happen to be grouped together in close enough proximity to make the collection of the waste economically possible. In the Columbia River region this plan as now actually applied results in the utilization of 800 tons from a total of 4,000 tons. In the Puget Sound region four of these stations conserve a total of 15,500 tons, out of a total of 38,750 tons. The scheme as suggested for ideal conditions, as well as when actually applied, it is reiterated, falls far short of meeting the demands of the problem.

THE SMALL BY-PRODUCTS PLANT OPERATED AS AN INTEGRAL PART OF THE CANNERY.

As the only alternative to the central rendering station, the suggestion is offered of a by-products plant operated as an intimate part of the cannery. This would be a small-unit plant of low capacity, just sufficient to treat the output in waste of the cannery of which it forms a part.

EQUIPMENT.

For equipment the old-fashioned, unimproved retort cooker and hydraulic press are recommended, not because they are regarded as ideal, but because they constitute the only apparatus which the writer has seen in successful operation on a small scale. It has been demonstrated, and is being demonstrated daily, that this form of apparatus will render salmon cuttings, affording a good grade of scrap and a fair yield of oil. The demonstration has not been confined to large-scale operations, but has been attempted on a small scale as a strictly by-products plant, with satisfactory preliminary results.

The equipment, as has been pointed out in a foregoing paragraph, consists essentially of retort cookers, a hydraulic press, and a drier of suitable form, heated by steam or hot air, as the experience and wisdom of the designer indicate. From a "one-line" cannery, or one with a maximum capacity of 900 cases per day of 12 hours, would be obtained a maximum of 18 tons of waste. This figure is based on the estimate of 40 pounds waste per case. The by-products plant possibly should have sufficient capacity to render this volume of waste in a run of six hours; that is, a capacity of 6,000 pounds

per hour. Such a high capacity is suggested in order that it may be insured that the steam required for cooking can be supplied by the cannery boilers. It is believed that the requisite steam surely can be withdrawn from these for a period of 6 hours out of the 24. This appears especially probable in view of the fact that the cannery is shut down almost invariably during some period of the day, and that while still running a varying demand is made on the steam capacity of the boilers. As has been observed in a foregoing paragraph, the dressing force may be at work and the machinery which they tend may be in operation when the steam boxes and cooking retorts, requiring a large amount of steam, are idle. If it can be shown that sufficient steam is available to operate the cooker for a longer period than the 6 hours suggested, the capacity of the rendering apparatus, and perhaps its cost, can be reduced proportionately.

In addition to the three above-mentioned pieces of apparatus, there would be required conveyors, a storage bin to receive the day's supply of raw materials, vats in which to recover the oils and storage capacity for the oils produced, and a house sufficiently large to inclose the apparatus and provide room for bagging and storing the output of dry scrap.

Unless the conditions are such that the waste can be sluiced directly, by gravity, into the storage bin, a conveyor must be provided to carry this from beneath the floor of the fish-cleaning house. The structure of this will depend on the angle at which it is required to work. Thus, if the conditions are such that a horizontal conveyor can be operated, all that is needed is a water-tight trough through which pass blocks or boards of wood, suitably attached to and actuated by the movement of a chain belt, to direct the flow of the waste and the water in which it is immersed. The cuttings from the "iron chink" may be made to fall into a hopper placed beneath, which deposits the waste upon the conveyor; likewise that from the other cleaning operations may be directed, in any suitable manner, upon the conveyor. From the storage bin the material is to be lifted by elevator and fed into the retorts. Therefore the bin should be constructed with a sloping bottom so that the last of the material contained therein will feed automatically into the conveyor. Strainers of woven wire should be inserted in the sides of the bin to permit the excess water to drain away. To accommodate the day's output in waste the bin must have a capacity of about 20 tons.

Two retorts of the upright, cylindrical form should be provided of about 5 tons capacity each, two offering the advantage over one of greater elasticity of operation. The daily output in waste of a one-line cannery, amounting to about 18 tons, could be rendered by the two retorts of the capacity suggested in two cookings each.

Whether the retorts should be of open type or closed to make possible cooking under pressure is debatable, as equally satisfactory results apparently are had from both types.

Beneath the retorts a "slush box," or bin, should be constructed, of sufficient capacity to hold the cooked fish from at least one retort, and provided with steam coils to keep its contents hot. As the material is to be drawn off from this onto frames for the press, it should be provided with suitable gate valves for that purpose and should be built at such a height that the material could be run onto the frames directly by gravity.

For pressing, at present the method previously described, involving the use of "hop cloth" envelopes for the material to be pressed and hydraulic power ("rack and cloth" press), must be recommended. This is slow and laborious, but effects an efficient separation; and at present it has the distinct advantage over all other methods of pressing salmon of having been demonstrated as entirely feasible.

In actual practice at least two men are required to operate the press. This number probably could not be reduced, as the placing of the frames and especially of the "hop-cloth" squares scarcely could be done by one man, as is true also of the removal of these after the pressing has been finished. An additional objection to this method of pressing is the difficulty of cleaning the frames and cloths. During the pressing they become covered with the finely divided cooked fish. This spoils readily unless removed. To clean them by hand, as now practiced, is a tedious method which certainly could be improved.

Adhering, again, to demonstrated forms of apparatus, the steam drier must be suggested (Pl. VI, fig. 1). A form employed with success in one small cannery by-products plant has the shape of a drum, 6 feet in diameter and 2½ feet deep. It is steam jacketed and therefore must be insulated. For heating it, steam under 20 pounds pressure is requisite. Paddles for stirring are attached to a vertical shaft which is actuated through suitable gearings by a small steam engine. A rotary fan serves to remove the moisture-charged air. An opening in the top is designed for filling, with another near the bottom for emptying. The latter operation is accomplished automatically when the paddles are revolved with the lower door open. The drier of the above dimensions receives a charge of 1,500 pounds of wet material. With this apparatus a small steam engine would be required. One of 15-horsepower capacity has been found sufficient to operate the drier and the conveyors of the plant.

As this drier has a rated capacity of only 1,500 pounds of wet material, and as it requires two hours in which to effect the drying, which is equivalent to 750 pounds per hour, its usefulness is limited to a plant of small capacity. To provide drying capacity for the maxi-

mum possible daily output of raw materials from a "one-line" cannery, amounting to 27,000 pounds, at least four of those would be required, a number which scarcely could be operated economically. This estimate is based on the supposition that the driers will be operated only six hours per day.

There are other forms of steam driers of more or less desirable design which could be adapted to the small-scale drying of scrap. However, no steam drier should be considered which does not provide for evaporation under vacuum or for the removal, at frequent intervals or continuously, of the moisture-saturated air. The efficiency of any other form necessarily must be low.

We believe that there are other possible forms of apparatus which could be operated more economically, and others again which would yield a higher efficiency, but these lack demonstration in actual practice and for the sake of conservativeness and fairness to all concerned are not recommended here. We have in mind, in this connection, continuous mechanical cookers and screw presses, of small capacities, capable of rendering in about 6 hours the waste resulting from a 12-hour run of the cannery. For a "one-line" cannery, packing 900 cases per day of 12 hours, it has been seen this would be 18 tons for the day, or 6,000 pounds per hour (900 cases, 40 pounds per case, rendered in 6 hours). To operate with these, a suitable drier, preferably continuous and automatic, must be installed. For this purpose a hot-air drier is recommended, one designed to utilize the waste heat from the boiler fires, or, more simply, a rotary, direct-heat, cylindrical drier, heated with petroleum burners. This, in order to keep pace with the cooker and press, would be required to have the capacity of about 1,800 pounds wet or 900 pounds dry scrap per hour. The latter figure is obtained by taking 15 per cent of the weight of the original raw cuttings as its equivalent in dry scrap. In the press the moisture of this would be reduced to about 50 per cent. Requisite mechanical conveyors for transporting the raw materials from the storage bin to the cooker and from one machine to another would make the entire operation automatic and would reduce the labor required to a minimum.

Another form of apparatus for small-unit rendering plants is the one-operation apparatus, referred to in a foregoing paragraph, which prescribes the cooking of the material to be rendered in a closed retort, under pressure of steam and with revolving knives or macerators, the withdrawal of the water and oil which rises to the surface, and the evaporation to dryness, under vacuum, of the solids remaining. Heat for both cooking and desiccation is supplied by steam. As the entire operation is performed in a closed vessel and as all gases and liquids are conducted out of the building in pipes, the process is inodorous. While it is automatic it is discontinuous. Low initial

expenditure for equipment and economy in operation are claimed for the process by its exploiters. From a priori considerations there appears no reason why the process should not fulfill its promised performance, though it does appear a little doubtful whether the oils can be liberated sufficiently by maceration and washing without bringing the material to such a fine state of subdivision that a great deal would be lost in the water drawn off with the oil, or too long a time would be required to permit the solids to separate by settling. At present, this apparatus has received no trial in the actual commercial rendering of salmon cuttings, and a positive opinion concerning it is not justified.

A comparison of the reports of analyses of salmon and menhaden scrap, respectively, as reported in this paper on page 33, will show that the amount of oil remaining in the salmon scrap is much higher than that in the menhaden. While this may be due to the difference in the respective methods of drying the two (an explanation further suggested by the lower oil content of the two samples of salmon scrap dried in hot-air driers and involving the supposition that oils are volatilized in drying), it also may be due to the fact that the oils are not so easily recovered from salmon as from menhaden. This constitutes an additional reason why some method, if feasible, should be adopted whereby a more complete recovery of the oil is possible. The limits of the press easily are reached.

With the abandonment of the press, the adoption of a system involving the use of an extractive recommends itself. The extraction of the oils with gasoline theoretically should be quantitative, and the exploiters of processes based on the use of this extractive claim a very high efficiency. The method consists of cooking the material to be rendered in closed retorts with steam. At the end of the cooking the water in the material is evaporated under vacuum. When the evaporation is complete, the dry residue is washed thoroughly with gasoline, which removes all but about 1 per cent (more accurately, 1 per cent of the weight of the dry scrap, according to the claims made for the process) of the oils present. The gasoline extract is drawn off from the scrap and distilled. The oil remains as a residuum, and the evaporated gasoline is condensed and recovered. It is reported that there is but a slight loss in gasoline. An additional advantage of the method is that all of the nitrogenous constituents of the fish are saved, while in the other methods there is an indefinite loss due to the solubility of certain of these in the water drawn off of or expressed from the cooked fish and thrown away. A further modification of the system, known as the Cobbwell system, is based on cooking in oil the material to be rendered, the oil being obtained from previous extractions. After cooking, the excess of oil may be drawn off, when the remainder is extracted with gasoline.

The output in scrap of the by-products department of the average cannery, one putting up 50,000 cases, would be not more than 115 tons for the season, or, on the basis of 900 cases for the maximum daily pack, not more than 5,000 pounds per day. For bagging this small amount of scrap no special apparatus need be installed, though bagging would be facilitated if the scrap were elevated to and delivered into a storage bin from the bottom of which it could be drawn off into sacks by the bagger as desired. As a sack is made to hold 100 pounds, 50 bags would be required for the maximum daily output. Adequate floor space must be available for spreading the scrap for cooling when first removed from the drier. Vats for receiving and for the subsequent treatment of the oil and water removed by pressing must be provided. These should be on a level below that of the press so that the oil and water can be delivered into them by gravity; or if this arrangement is not convenient, a pump should be provided for raising the liquids to the vats. In either case, some sort of vat must be constructed beneath the presses as a temporary receptacle for these.

To separate the water and oil, the mixture should be allowed to stand in a vat, being kept hot by steam coils. The oil rising to the surface should be permitted to flow over a weir into a second vat, while the water is drawn off through a lower opening. If found desirable, an arrangement may be provided for drawing off likewise the finely divided solids which settle to the bottom of the vat. For effecting a simple purification of the oil, the second vat should be equipped with steam pipes with perforations so that steam may be bubbled into the oil. Then it may be drawn off into a tank for storage, or directly into barrels for shipment. The total output in oil from the suggested plant would not be more than 20,000 gallons, assuming a yield of 25 gallons per ton of raw material rendered; or, 450 gallons as the maximum daily output.

COST.

APPARATUS.

While the cost of a plant will be determined, of course, by a number of interdependent circumstances, the following estimates will serve to convey some idea of the outlay required to equip a by-products plant for a one-line cannery. Vats of sheet iron of about 5 tons capacity are obtainable for $350 each. A press may be obtained for as little as $300, or $800 may be paid for it, depending on the nature of the press. Driers of the type mentioned cost not more than $600. For a capacity of 4,500 pounds per six hours, six of these would be required. For the purchase of conveyors and other sorts of equipment, such as pipes, etc., and their installation, it is estimated that $1,000 would be adequate. A building 20 feet

by 50 feet doubtless would be large enough, which could be erected, perhaps, for about $2,000. In the following table the probable costs are itemized:

Costs of apparatus.

Retorts, 2, at $350	$700
Press	550
Driers, 2, at $600	1,200
Engine to operate driers	350
Incidentals	1,000
House	2,000
Total	5,800

OPERATING EXPENSES.

As the hypothetical plant is to be run at night, or at times when the cannery boilers are not carrying their maximum load, it is probable that an extra engineer and fireman would have to be employed. In addition to these, three other laborers should suffice. At $100 per month for this engineer and $75 each for the fireman and the three laborers, the outlay for labor for the two months would be $800.

To sack 115 tons dry scrap, putting 100 pounds in a sack, 2,300 sacks would be required. These, at 10 cents each (a price which includes the cost of the necessary string also), would amount to $230.

From 750 tons of raw material, the amount rendered per season, about 19,000 gallons of oil would be produced. To contain this volume 380 barrels, of 50 gallons capacity, would be necessary. These are purchasable at $1.85 each, necessitating a maximum outlay of about $700 for barrels.

To render garbage, it is stated, 25 pounds of bituminous coal is required per ton of garbage rendered. On this basis, to render 750 tons of cannery waste, 9.5 tons of coal would be required. This would cost, on the Alaska coast, $76 (9.5 tons at $8 per ton). An additional outlay for coal, for estimating which reliable data are lacking, would be occasioned by the operation of conveyors and driers.

An additional estimate, of doubtful value, of the amount of coal necessary to dry the cooked scrap can be secured by considering the actual amount of water to be evaporated in drying this and the quantity of heat necessary to evaporate a given quantity of water. The wet material coming from the presses consists of about 50 per cent of water and 50 per cent of solids. To prepare 120 tons of dry scrap, an equal weight of water must be evaporated. To evaporate this in a closed vessel would require 12 tons of coal, on the basis of 1 part of coal to 10 of water. This would cost $96.

A further item which must be considered in Alaska is freight charges on products.

The running expenses, then, may be put as follows:

Interest on investment, $6,000, at 10 per cent	$600
Depreciation, at 10 per cent	600
Wages, 1 man at $100, 4 at $75 per month, 2 months	800
Sacks, 2,300, at 10 cents	230
Barrels, 380, at $1.85	700
Coal for rendering, 10 tons, at $8	80
Coal for drying, 12 tons, at $8	96
Freight (from Alaska) on 120 tons scrap at $4	480
Freight (from Alaska) on 380 barrels oil, 75 tons, at $4	300
Total	3,886

The proceeds may be estimated as follows:

Scrap, 115 tons, at $40	$4,600
Oil, 19,000 gallons, at 30 cents	5,700
Total proceeds	10,300
Total expenses	3,886
Balance	6,414

According to the above estimate $6,414 are put down as profit. More strictly this should be regarded as the working margin of income over expenses. As the conditions imposed are more severe than those probably to be encountered, it is believed that this estimate is conservative. This belief is strengthened by the fact that the estimates on the same general basis, prepared by an experienced manufacturer of fish scrap from this class of material, is 50 per cent lower than the above as concerns the running expenses and 20 per cent lower with respect to equipment. Thus, a larger capacity is prescribed than probably would be necessary, and a much shorter working day than would be required in actual practice.

In operating the supposed by-products plant, the labor problem is regarded by those packers who operate in Alaska as a serious matter. This may be the case in western Alaska, where it may be necessary to employ the force for the by-products plant before leaving the States and to carry them on the pay roll until they return in the fall; but in the other parts of Alaska it is difficult to see how the problem of securing three or four additional laborers could be serious. While it is probable that in the busiest part of the season every member of the cannery force is employed, at other times there should be a sufficient number of men temporarily idle to do all the work required in the by-products plant. An additional force, if necessary, could be secured for the rush season.

ADVANTAGES OF THE BY-PRODUCTS PLANT.

FINANCIAL.

There are three decided advantages possessed by this system of disposing of cannery waste. The first and most striking is that of

the elimination of all costs of collecting. With these disappear likewise the worry incident to the numerous elements of uncertainty involved in collecting. Thus at once are eliminated tugs and scows and their crews. The expense of collecting is but a trifle more than that of disposal by dumping through the cannery floor, and is decidedly cheaper than the method resorted to by some canneries.

As the producer and consumer of the raw materials are one and the same, the conflict between the interests of the two disappears. Contracts working a hardship upon the one or the other are an objectionable feature of the central rendering station plan as actually practiced.

With a strictly by-products plant, overhead charges disappear. The cannery already has its clerical force and its sales and purchasing departments, which, without any increase in their force, are quite able to handle the slight additional labor incident to the by-products plant. Likewise it has the assistance of experienced foremen and mechanicians regularly attached to the cannery force, and the use of the supplementary equipment, such as machine shops, of the cannery. Likewise, the docks, and frequently the unused floor space of the cannery, can serve to cut down the initial expenditures.

OTHER ADVANTAGES.

The advantages other than monetary to accrue from the preservation of the cannery waste perhaps equal the financial advantages. The main item gained, of course, is the greatly enhanced sanitary condition of the cannery and its environs. To discuss here the moral effect of the most economical utilization of the fish now given to the packers "for the taking" on the residents of the State with which the packers come into important contact, perhaps, is too far afield for the purposes of this bulletin. The suggestion of such an advantage is made for what it is worth.

THE PRODUCTION OF A MIXED FERTILIZER FROM FISH SCRAP AND KELP.

KELPS.

Since the shortness of the season during which the proposed central rendering station would be in operation has been suggested as a great obstacle in the way of the commercial success of that project, it becomes highly desirable to find some other use to which the equipment of the plant could be applied during seasons when no cannery waste would be available for rendering. All along the Pacific coast from Mexico to Bering Sea there is a vast quantity of fertilizer materials, the giant kelps, whose values are recoverable by a process similar in part to that prescribed for the conversion of

cannery waste into fertilizer, and adequate supplies of these are found near certain of the centers of the salmon-canning industry. It originally was supposed that the rendering of the cannery waste could be made to serve as an auxiliary operation to the treatment of kelp. After investigation it appears more probable that it would be found necessary to make the curing of kelp supplementary to the rendering of fish waste, since the apparatus required for the latter is much more elaborate than that for the former.

The term "kelp," formerly applied to the ashes of seaweeds, now has come to mean any of the brown marine algæ. In general use its meaning has become restricted to the large and conspicuous sea algæ of the Pacific coast. The so-called giant kelps of the Pacific coast may be defined as four species of the marine algæ, whose botanical names are *Pelagophycus porra*, *Alaria fistulosa*, *Nereocystis luetkeana*, and *Macrocystis pyrifera*, named in the reverse order of their present economic importance. Only two of these, the latter two, at present should be considered in a fertilizer connection, as of the former two, the *Pelagophycus porra* occurs in too small quantities to be important, though it carries a very high proportion of valuable fertilizer ingredients, and the *Alaria fistulosa* is too low in potassium to merit treatment where the other kelps are available in sufficient quantities.

The Nereocystis is an annual whose seasonal growth attains an average of 50 feet. The rapid growth necessary to reach such a size in a growing season denotes an abundant supply of the elements or compounds which enter into the plants' metabolism, and this, in turn, indicates a large and constantly changing volume of the medium in which it grows. Thus it is found in localities of heavy surf or strong tideways. To maintain itself in position under these conditions it must attach itself firmly to the bottom. Therefore a rocky bottom is essential to the establishment of groves of the plants. To attach itself, the plant develops a "holdfast," a rootlike growth which tends to grow around and grasp the objects with which it comes in contact, thus anchoring the plant. Extending upward from the holdfast is the stipe, a long, slender stem, cordlike and tough, which reaches almost to the surface of the water. Toward its upper end it gradually enlarges, becoming hollow, and culminates in a hollow bulb. This portion, being air filled, serves to float the plant, and is called the pneumatocyst. The plant thus is lifted and held in the sunlight. From the top of the pneumatocyst develop two tufts or bunches of long, ribbonlike leaves, called fronds, which grow 10 or 15 feet in length and trail out in the tidal currents. The most interesting characteristic of the plant, and a characteristic that distinguishes it from the other important kelp, the Macrocystis, is that almost the entire plant, on the basis of weight, lies on or at the

surface, from the enlarged portion of the stipe upward. This fact has an important bearing on the harvesting of this species, as cutting the stipe a few feet below the surface severs practically the entire plant.

The Macrocystis, a perennial, reaches an average length of 100 feet and grows likewise in regions favored by a rocky bottom and a swift tideway or heavy surf. It attaches itself in the same manner as does the Nereocystis—which is characteristic of the kelps—but instead of a single stipe extending from the holdfast it develops a number, which give the effect of a bushy or branching plant. The fronds are distributed along the entire length of the stipe. These reach a maximum of about 3 feet in length and decrease in size as the upper or younger end of the plant is approached. A short section of stem connects the frond to the stipe and bears a pear-shaped enlargement, which is hollow and serves as the pneumatocyst. The plant does not stop growing on reaching the surface, but a large portion of its length lies upon the surface, supported by its numerous pneumatocysts, and trails out in the tidal currents.

Reproduction by these species is by means of sporangia, small bodies which develop on the fronds, in the case of the Macrocystis on the old fronds near the bottom, and which are thrown off to find lodgment and develop into new plants. As the Nereocystis is in effect an annual, its continuance is dependent on annual reseeding. While plants have been observed which have withstood the winter's cold and storms, thus appearing to be at least a biennial, most of the groves are torn out by storms during the winter and re-formed during the following summer. In harvesting these groves, then, due precautions must be taken to leave enough plants for resporing, or to postpone harvesting until after the sporing season. In the case of the Macrocystis it is probable that no such precautions need be observed.

In this connection it should be said further that only one harvesting per season of the Nereocystis is possible, since cutting that plant a few feet below the surface of the water, as pointed out, severs the entire growing portion. It is necessary, then, to await the new growth of the next season.

Such is not the case with the Macrocystis. Cutting that plant a few feet below the surface of the water severs only the upper part of the growing portion, possibly one-half, and does not kill the plant. On the contrary, there seems to be a certain stimulation in growth exhibited by a sort of "stooling" effect; while the old stipes slowly decay, fresh shoots appear, resulting in a thicker growth. It is estimated that after a cutting, a grove resumes its original condition after a lapse of 40 to 60 days.

DISTRIBUTION AND QUANTITIES.

On the Pacific coast of the United States the two commercially important kelps, Nereocystis and Macrocystis, characterize, respectively, the northern and southern stretches of that coast. While it is true that they are found together at certain places and that either one or the other occurs in thin fringes or patches along the entire length of the coast, the Nereocystis occurs in large and thick groves in the Puget Sound region and the Macrocystis on the California coast south of Point Sur. In southeastern Alaska large groves of both species occur; and in western Alaska, in the neighborhood of Kodiak Island and the mouth of Cook Inlet, the Nereocystis is found.

The important groves from the Mexican boundary to the Canadian line on Puget Sound during the past three years have been measured and mapped to scale; likewise, the important groves of southwestern and western Alaska have been surveyed.[1] As a result of the three years' work, it is known pretty definitely what the available quantities of kelp are in the various sections of the coast. Economically, the important groves group themselves around certain centers where there are harbors and where labor and transportation facilities are favorable. The natural centers are Puget Sound, Santa Barbara, San Pedro, and San Diego, on the coast of the United States, and Ketchikan and Kodiak, in Alaska.

The Puget Sound groves, it is estimated, can be made to yield 390,000 tons of wet kelp per year. The principal grove here, in convenient reach of Bellingham or Anacortes, is the Smith Island grove, which, it is calculated, would produce 100,000 tons per season. Other important groves lie near the American shore of the Strait of Juan de Fuca (85,000 tons) and the San Juan Islands.

Opposite Santa Barbara is a grove of approximately 3.9 square nautical miles, which would yield about 320,000 tons of wet kelp per cutting. Near San Pedro, extending from Point Fermin to Malaga Cove, are two groves of a joint area of 2.4 nautical square miles which at a single harvesting should produce 194,000 tons of wet kelp. Near San Diego, north of Point Loma, likewise are two groves of a combined area of 7.7 nautical square miles from which could be harvested at one cutting about 633,000 tons.

In southeastern Alaska 70 square miles of kelp beds have been surveyed, carrying about 8,000,000 tons of wet kelp. These are distributed along a coast line of about 6,000 miles in a region of many

[1] The groves of the Pacific coast of the States were surveyed by Capt. W. C. Crandall, of the La Jolla Marine Biological Institute; those of Puget Sound and Alaska, by Profs. T. C. Frye and G. B. Rigg, of the University of Washington.

islands and circuitous fiords and arms of the sea. While the length of the shore line, relatively speaking, is enormous, the actual distances from point to point are not great. Thus the entire area of this portion of territory is about 25,500 square miles, which is about the area of the States of New Hampshire, Vermont, and Massachusetts.[1] Of the amount of kelp surveyed, groves containing 2,880,000 tons are regarded as easily available, the availability being estimated on the basis of quietness of water and freedom from rocks and other obstructions to navigation.

The kelp of this region has been grouped around eight centers, which are:

1. Port McArthur, near the south end of Kuiu Island.
2. Shakan Bay, on Sumner Strait.
3. Tyee, near Point Gardner.
4. Duke Island, possibly inside the Vegas Islands.
5. Saginaw Bay, at the north end of Kuiu Island.
6. Warren Cove, on Warren Island.
7. Barrier Island, between Cape Chacon and Cape Muzon.
8. Bay of Pillars, on Chatham Strait.

These points have been selected by Prof. Frye from the viewpoint of amounts of available kelp and convenience of harbor.

In this region, as well in western Alaska, large and heavy groves of *Alaria fistulosa* occur. This is a kelp which attains great size, but carries only a small proportion of potash. Its nitrogen content is correspondingly high, but not high enough to make it of equal commercial importance with the other two species.

The kelps of western Alaska so far mapped (by Prof. G. B. Rigg, of the University of Washington, during the summer of 1913) contain about 3,500,000 tons of green kelp, the estimate being based on the supposition that the kelp would be cut about 5 feet beneath the surface. The species included are both Nereocystis and Alaria. "Of this, 1,251,200 tons are in beds of pure Nereocystis; 1,457,300 tons are in beds of mixed Nereocystis and Alaria.[2]

Large kelp beds are within easy reach of the harbors of Port Graham, Seldovia, Kodiak, and Alitak, on Olga Bay.

COMPOSITION.

The composition of the kelps here is considered only from the point of view of their fertilizer value. In the following tables are given the respective composition of a number of samples of Nereocystis

[1] From the report of Dr. T. C. Frye on the Kelps of Southeastern Alaska, Rept. 100, U. S. Dept. of Agr., Part IV.

[2] G. B. Rigg, report on the Kelps of Western Alaska, ibid., Part V.

and Macrocystis, collected from various localities through a number of years and analyzed in the laboratories of this bureau. These tables are made up of results published elsewhere by the writer,[1] Lindemuth and Parker,[2] and Merz.[3] The samples may be regarded as average samples, since they were collected only as representative of the groves distributed along the coast.

TABLE X.—*Chemical composition of Nereocystis.*

Location.	K_2O.	I.	N.	Organic matter.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Fresh Water Bay, Puget Sound	18.04	0.23	2.26	51.13
	17.61	.24	2.21	51.11
	31.62	.25	1.21	33.15
	16.92	.20	2.57	51.16
	17.05	.24	2.71	51.67
	17.32	.28	2.53	50.12
	16.20	.19	2.54	52.14
	16.50	.30	2.21	37.40
	16.72	.20	1.46	39.02
San Juan County, Wash	25.70	.08	1.29	41.80
	13.30	.15	2.52	61.50
	23.00	.17	1.32	46.20
	16.20	.15	2.32	35.30
Point Arena, Cal	16.72	.13	2.22	53.56
	20.62	.15	2.25	51.42
Bay of Monterey, Cal	16.96	.20	2.15	57.25
	23.82	.17	2.41	47.26
	21.70	.18	1.58	50.20
Point Pinos, Cal	19.40	.12	1.70	53.00
	26.10	.15	1.12	40.60
Cayucos, Cal	20.83	.24	1.93	47.86
Geese Island, Alaska	28.26	.06	1.06	43.52
	15.44	.14	2.27	56.26
Port Graham, Alaska	24.69	.06	1.15	40.50
	14.78	None.	2.02	42.74
Pearse Canal, Alaska	12.74	None.	2.87	60.50
	23.88	None.	1.53	39.90
Between Tongass and Kanagunut Islands	15.12	.07	3.06	55.56
	30.12	.05	1.07	33.50
Gulf of Esquibel, Alaska	27.02	None.	.81	39.92
55° 37′ N., 133° 28′ W	19.63	None.	1.04	49.28
Eagle Island, Davidson Inlet, Alaska	16.74	.06	1.52	51.60
Wrangell Straits, Alaska	24.80	.03	.98	42.78
55° 54′ N., 133° 30′ W	28.76	None.	.59	32.66
56° 36′ N., 133° 57′ W	17.67	.01	2.01	50.62
56° 12′ N., 133° 40′ W	20.12	.06	1.85	48.56
56° 08′ N., 133° 54′ W	26.05	.10	1.46	43.78
55° 36′ N., 132° 57′ W	21.61	.09	1.65	43.50
57° 01′ N., 134° 34′ W	22.73	Trace.	1.54	55.56
Average	21.49	.11	1.80	47.75

[1] J. Ind. Eng. Chem., 4, 9 (1912).
[2] J. Ind. Eng. Chem., 5, 287 (1913).
[3] J. Ind. Eng. Chem., 6, 19 (1914).

TABLE XI.—*Chemical composition of Macrocystis.*

Location.	K_2O.	I.	N.	Organic matter.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Low Point, Wash	12.80	0.23	1.37	59.40
Neah Bay, Wash	19.60	.20	1.81	51.50
Pillar Point, Cal	17.26	.15	2.18	58.14
	27.66	.14	1.00	41.04
Santa Cruz, Cal	16.44	.24	2.16	59.80
Monterey Bay, Cal	18.30	.26	2.32	57.00
	12.38	.18	2.11	68.80
Point Aulon, Cal	23.00	.32	1.83	51.20
Point San Luis, Cal	8.62	.14	2.35	68.26
Rocky Point, Cal	9.35	.25	2.72	73.06
Point Conception, Cal	14.17	.24	2.15	62.95
San Miguel Island	16.40	.29	1.54	50.60
Santa Cruz Island	17.40	.32	1.57	49.40
Anacapa Island	12.60	.26	.95	64.40
Cape Quemada, Cal	14.10	.29	.90	63.50
Goleta Point, Cal	16.70	.17	1.00	56.70
Point Las Pitos, Cal	12.30	.20	.98	66.20
La Jolla Point, Cal	13.60	.38	1.04	64.40
Point Medanos, Cal	13.40	.23	.74	62.90
Point Loma, Cal	15.70	.15	.90	60.90
Between Duke Island and Bee Rocks, Alaska	11.49	.06	1.08	67.34
56° 21′ N., 133° 36′ W	8.63	None.	2.68	72.24
57° 13′ N., 133° 34′ W	6.92	Trace.	2.69	73.96
57° 01′ N., 134° 34′ W	7.30	None.	2.19	73.24
55° 22′ N., 133° 16′ W	13.26	.10	1.25	64.36
54° 58′ N., 132° 29′ W	22.48	.30	2.64	49.02
Average	13.63	.19	1.83	63.00

In these tables the potash is recorded as such—that is, as the oxide, the conventional manner of expressing the potassium content of fertilizers. It must not be understood that this is the form in which it occurs in the plant. When the plant has been incinerated at low heat, so that all volatile organic matter has been driven off and only charcoal remains, and leached, potassium chloride is obtained. While it is not known definitely what compound of potassium exists in the living plant, it may be regarded as potassium chloride. In addition to the potassium chloride, sodium chloride is present in varying amounts, roughly equal to about one-third that of the potassium chloride. Also, there are small quantities of phosphoric and sulphuric acids, calcium, and magnesium. By lixiviation practically all of the soluble salts, principally of potassium and sodium, are removed. If the remaining charcoal then be burned, an ash remains which consists essentially of calcium and magnesium carbonate and phosphate. The percentage of ash varies from 3 to 12 per cent, the variations being determined by the part of the plant undergoing analysis. The stipe carries a much higher proportion of ash than the leaves or fronds.[1]

[1] For analyses of the various kelps of the Pacific coast other than and including those of commercial importance, and for others of various algæ of various parts of the world copied from the literature, see App. P of S. Doc. 190, Sixty-second Congress, second session.

From the results of analyses recorded above the following generalizations have been made:

(1) No definite quantitative relations exist between the different constituents of kelp.

(2) The potassium content of Nereocystis is greater than that of Macrocystis.

(3) The potassium content of northern kelp is higher than that of southern kelp.

(4) There is no positive difference in iodine content between northern and southern kelps.

The following conclusions also seem justified:

(5) The proximity of the mouth of a fresh-water stream has no appreciable effect on the potash and nitrogen content of kelp.

(6) There are no essential differences between the potash and nitrogen content of fronds and stipes.[1]

KELP AS A FERTILIZER.

In the British Isles kelp has been used as a fertilizer for centuries. So highly was it valued that lands carrying kelp-harvesting privileges were especially valuable. In New England, also, kelp or seaweed has found favorable use as a soil amendment. In Alaska, especially on Kodiak Island, near the village of Kodiak, and in the neighborhood of Skagway, it is used in like manner, on the former island particularly in fertilizing potatoes and in the latter region on truck gardens.

The Pacific kelps are markedly different from the seaweeds of the Atlantic coast, especially in their very much greater size and their relatively large content of potassium chloride. It is these two qualities that give them especial importance as a possible source of fertilizer materials.

In the regions mentioned kelp has been applied to the soil as a mulch in its green state, or, better, after it has been cured by drying in the sun, or rotted by being allowed to stand in heaps.

For several years past kelp has been harvested mechanically near San Pedro, Cal., and shipped in the crude, undried condition to the ranches and orchards of that part of the State. As the green kelp, after draining, contains about 85 per cent water, its content of potash and nitrogen are about 2.6 per cent and 0.3 per cent, respectively. These values are obtained by calculating back from the values established on the dry basis to that of a content of 85 per cent water.

The manurial value of green kelp, as compared with a number of other materials commonly used as fertilizers, is brought out in the following table:[2]

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[1] Cameron, Kelp and Other Sources of Potash, J. Frank. Inst., October, 1913, p. 363.
[2] Cameron, loc. cit., p. 377.

TABLE XII.—*Comparison of the composition of wet kelp with other manurial products.*

Material.	Moisture.	Nitrogen.	Potash.	Phosphoric acid.
Horse manure:[1]	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Solid fresh excrement	.....	0.44	0.35	0.17
Fresh urine	.....	1.55	1.50	.....
Stable manure[1]	73.27	.50	.60	.30
Green alfalfa[1]	75.30	.72	.45	.15
Cowpeas[1]	78.81	.27	.31	.98
Street sweepings, Washington, D. C.[2]	.....	.86	.55	.55
Wet kelp	85.00	.30	2.50	.10

[1] From Soils, by S. W. Fletcher.
[2] From Analyses, by J. G. Smith, Bureau of Soils.

The high content in water of the green kelp and its resulting low content in valuable constituents restricts its use to regions within easy reach of the points where it is harvested. For that reason any scheme for the large-scale utilization of kelp as a fertilizer must be based on some method of concentrating its valuable constituents. Since all of these are either neutral or beneficial from a fertilizer point of view, it is necessary only to concentrate them by the removal of the water, or in other words by drying. After an investigation of several years and a careful consideration of the nature of the raw materials involved, the value of the products obtainable and the costs of obtaining them, together with the demands of the fertilizer trade and the economic conditions existing on the Pacific coast, it appears that kelp, in the beginning at least, most advantageously can be prepared for the fertilizer trade merely by drying and grinding.

The product obtainable, as shown by small-scale operations, is a coarse gray powder of such specific gravity that a cubic foot weighs 51 pounds. While it does not absorb moisture readily from the air, when wetted it swells and may become sticky and gelatinous.

In composition it would approximate closely the values obtained from the foregoing Tables X and XI. The drying would not be quantitative; that is, a certain proportion of water would be allowed to remain, probably 7 to 10 per cent. Assuming the larger figure, the other values would be reduced proportionately, namely, 10 per cent. The pulverized kelp, then, would contain 15.8 per cent potash and 1.6 per cent nitrogen. On the retail market of the Pacific Coast States, the prices of $1 per unit of potash and $3.30 per unit of ammonia are obtainable. On this basis the value of the kelp per ton is arrived at, as follows:

15.75 per cent K_2O at $1	$15.75
2.18 per cent NH_3 at $3.30	7.19
Total value per ton	22.94

In the wholesale market of the East, the prices obtainable are $0.65 per unit of potash and $2.85 per unit of ammonia, on the basis of which the value of the kelp would be:

15.75 per cent K_2O at $0.65	$10.24
2.18 per cent NH_3 at $2.85	6.21
Total value per ton	16.45

From the analyses of the dry kelp it is seen that it is distinctly a potassic fertilizer, and would enter the trade as a potash carrier. Since the present practice is to use the mixed or "complete" fertilizers, the kelp, if produced on a large scale, would find its market as a potash carrier to be mixed with phosphates and ammoniates to form the "complete" fertilizer. For this purpose, it would enter into competition with other potash carriers, including the German potash salts. These are, principally, kainite, a double salt of potassium and magnesium, $MgSO_4KCl3H_2O$, and "manure salts," a mixture of potassium, sodium, calcium, and magnesium salts. Kainite, when pure, has a theoretical content of 18.9 per cent potash, but in the impure condition in which it is found on the market carries about 12.5 per cent potash. It sells for about $8.25 per ton. "Manure salts" vary widely in their potash content, but generally are of low grade and carry about 12 to 18 per cent potash. At present kainite, as such, is disappearing from the market, being classified with "manure salts."

A comparison of the efficiency as a fertilizer of the potash in kelp and that in potassium salts, of the general type used in mixed fertilizers, has been made in the laboratories of this bureau by Skinner and Jackson.[1] The two were applied to growing plants in equivalent amounts. The results showed that the kelp as a potassic fertilizer was quite as effective as the potash salts.

Since sodium chloride is found as a constituent of kelp, it has been suggested that its use on alkaline soils might prove objectionable. In reply to this it should be said that the amount of salt actually added to the soil in the kelp is extremely small, and in such amounts it has been shown to exhibit fertilizing properties. Further, sodium chloride makes up but a small proportion of alkali, that being either sulphate of calcium or magnesium or carbonate of soda. If such an objection were valid, it would apply much more to the materials now in use as potash carriers, the "manure salts," which have been seen to contain soluble salts of both calcium and magnesium. In the case of the potash salts, the constituents other than potash have no value on a fertilizer basis and therefore are merely so much inert material on which transportation must be paid. The deleterious action of these in some soils would be un-

[1] Circ. 76, Bureau of Soils, U. S. Dept. of Agr.

doubted if the fertilizers of which they form a part were used in very great amount. They are objectionable on the further score that they render the material of which they form a part hygroscopic, which property in moist air causes the fertilizer to cake. The ingredients of kelp other than potassic, it has been shown, are salt and organic matter, the nitrogen of which, rated as ammonia, adds materially to the market price of the product. The organic matter itself is of value, as contributing—to a small extent, to be sure—to the organic constituents of the soil, known by the indefinite term of "humus."

PREPARATION OF DRY FERTILIZER FROM KELP.

Since the ingredients of kelp are either neutral or beneficial in their influence on plant growth, to prepare kelp for use as a fertilizer it is necessary only to convert it into a form in which it can be preserved and shipped. To accomplish this it is sufficient to harvest, drive off the water which it contains, and grind it to a coarse powder for bagging and mixing.

Kelp is being harvested by a machine which embodies the principles of the mowing machine or reaper used in harvesting agricultural products. The harvester actually in operation consists essentially of a barge over the end of which projects an adjustable frame, supporting an endless belt, tilted to form an inclined plane. Across the lower end of the belt extends a horizontal cutting bar about 10 feet in length, of the type used in the construction of reapers, which is supplemented at each end by two perpendicular knives. By this arrangement a swath may be cut through the kelp 10 feet in width and of a depth determined by the adjustment of the supporting frame. Back of the knives the belt, constructed of chains and netting, is operated in such a way as to catch the severed kelp and lift it upon the barge. Beneath the upper end of the belt is a chopper into which the kelp drops and by which it is cut into short lengths. From this it passes onto a short conveyor which loads it into a large scow made fast alongside. The small barge carrying the cutter is moved along the side of the large scow so that the load of cut kelp is distributed evenly. To operate the moving parts of the machine a gasoline engine is provided. The barge and scow are pushed through the kelp groves by a launch, which serves also to tow them to the dock for unloading. (Pl. VI, fig. 2.)

The cost of cutting will be determined by the conditions obtaining at the place of cutting. The results obtained so far indicate that this will be not more than 50 cents per raw ton, and easily may be reduced to 25 cents or less, inclusive of unloading at the dock.

It can not be expected that the cutter now in operation embodies all the perfections to which such a machine is susceptible, nor that

improvements in the machine will not reduce the cost of cutting. Certain features of the present method of operation are objectionable. But these almost certainly will disappear when a fuller experience shall have pointed them out and the means of circumventing them. Cutters of other forms and modifications of the present cutter have been designed and patented. Conspicuous among these are machines ascribed to S. A. Knapp (U. S. Patent No. 756,658) and George H. Ennis (U. S. Patent No. 1,080,144). In spite of its imperfections, the kelp cutter now in operation must be regarded as an unqualified solution of the problem of the economical harvesting of kelp.

The chopped kelp may be unloaded at the dock by an elevator such as that recommended for unloading cannery waste. In fact, the identical elevator may be employed in the same manner as in unloading the other class of material.

The drying of such materials as fish pomace, a class in which kelp likewise may be included, has been discussed in foregoing paragraphs. It should suffice to say here that from a priori considerations, as well as the results gotten so far in actual experimentation with kelp in the large-sized, hot-air drier and on a semicommercial scale, this type of drier seems entirely adapted to the drying of kelp.

Since, under Atlantic coast conditions, fish pomace containing 55 to 60 per cent water may be dried in the direct-heat rotary drier at a cost of about 50 cents per dry ton, it seems reasonable to believe that it should be possible to dry kelp, containing 85 to 90 per cent water, at a cost of $1 per dry ton. After drying it may be found desirable to grind the kelp for mixing. Dry kelp, especially when hot, is quite brittle and grinds easily.

Frye, in his work on Alaskan kelps, has shown that the leaves of Nereocystis yield 9.2 per cent solids and the stems 7.2 per cent, and that the Macrocystis, stems and leaves together, yields 13.27 per cent solids. *Alaria fistulosa* produces 13.74 per cent solids. These results were obtained by weighing specimens immediately on being taken from the water while they were still wet with sea water. On the basis of these values and the analyses given in the foregoing tables the following calculations have been made, showing the yield in various constituents to be expected from a definite weight of freshly cut kelp:

TABLE XIII.—*Yield in various constituents to be expected from 1,000 tons of freshly cut Macrocystis and Alaria.*

Variety of kelp.	Wet kelp.	Dry kelp.	K_2O.	N.
	Tons.	*Tons.*	*Tons.*	*Tons.*
Macrocystis	1,000	132	25.3	2.2
Alaria	1,000	137	13.3	3.6

TABLE XIV.—*Yield to be expected from 1,000 tons of Nereocystis.*

Material.	Leaf.	Stem.	Total.	Remarks.
	Tons.	*Tons.*	*Tons.*	
Wet kelp	775	225	1,000	Counting 3½ times as much leaf as stem.
Dry kelp	71	16	86	Leaves average 9.2 per cent dry; stems, 7.2 per cent.
K_2O	12	4	16	Leaves, 17.05 per cent K_2O; stems, 26.45 per cent K_2O.
N	1.54	.17	1.7	Leaves, 2.16 per cent N; stems, 1.09 per cent N.

A COMBINED FISH SCRAP AND KELP FERTILIZER PLANT.

One of the objections to the idea of a central rendering station for the treatment of cannery waste is the great length of time when the plant and its equipment lies idle. To overcome in part this objection it has been proposed that the fish-rendering plant, at times when fish waste is not available, be applied to the preparation of kelp fertilizer. More accurately, the suggestion is that the rendering of fish waste be resorted to as an operation auxiliary to the treatment of kelp. But as the rendering of fish waste requires more specialized apparatus than the drying of kelp, it appears more plausible to regard the treatment of kelp as subsidiary to the former.

With a plant fully equipped for the large-scale rendering of fish waste, all the equipment necessary for treating kelp, with the exception of a kelp harvester, has been supplied. Scows and tugs designed for the collection of cannery waste can be applied to the harvesting of kelp. The unloading elevators, storage bins, and conveyors within the plant are entirely adaptable to chopped kelp. Since the kelp is not to be cooked or pressed, the conveyors should be arranged with a view to the transference of the material directly from storage bin to drier. And the drier, of whatever form, probably would be found quite suitable for drying kelp.

Assuming the canning season, for example, in the Puget Sound region to be confined to the months of July and August, the equipment of the rendering station can be applied to the treatment of kelp during the months of September, October, and probably November, thus more than doubling the activity of the plant. The capacity of the drier, for the plant proposed in the foregoing paragraphs, in actual practice is about 50 tons per day, which is equivalent to about 500 tons of wet kelp. Furthermore, even during the canning season, when the amount of fish waste available is not sufficient to keep the plant running at full capacity, kelp may be harvested and dried as a supplementary operation.

The following estimates may serve to convey some idea of the cost and profits to be expected from the supplementary operations on kelp. Since the drier has a capacity of 50 tons of dry kelp, the capacity of the plant is limited to the equivalent weight of green kelp, which, on the basis of 10 per cent solids in the green, is 500

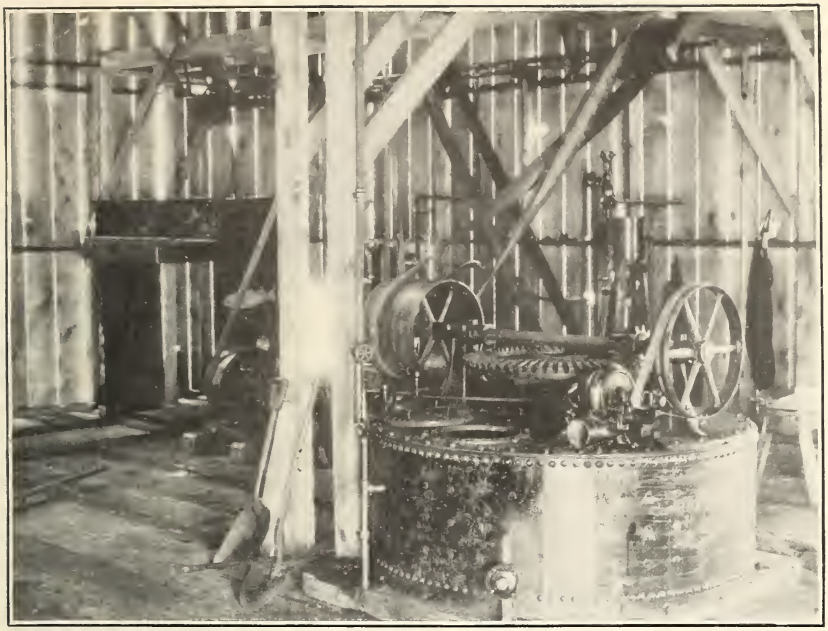

FIG. 1.—SMALL STEAM DRIER USED IN SALMON-CANNERY BY-PRODUCTS PLANT.
In the background the press is seen.

FIG. 2.—A KELP HARVESTER AND BARGE LOADED WITH HARVESTED AND CHOPPED KELP.

tons. This, it is assumed, could be harvested and unloaded at 50 cents per ton. Such an amount of material probably would require at least two cutters and five barges of 100 tons capacity each; and to tow these to the factory dock, two tugs would be necessary.

During the season when cannery waste is being collected, the labor required would be on wages, whether actually employed or not. Under such circumstances the labor cost need not be considered, but only the actual expense of operating the tugs and cutters. After the close of the cannery season, however, the cost of labor would have to be borne by the kelp. Any estimate of this cost would be difficult and perhaps misleading, but it scarcely would be under $50 per day. About one-half of this estimated cost of labor would be included in the cost of harvesting, and the balance in the cost of drying and sacking. The drying, it is estimated, would cost $1 per dry ton. To sack the product $2 per dry ton is a fair estimate, as a sack would hold over 100 pounds; the bags would cost something less than 10 cents each, including string.

The principal expenses of operation may be itemized as follows:

Harvesting, 500 tons, at 50 cents	$250.00
Drying, 50 tons (dry), at $1	50.00
Bagging, 50 tons, at $2	100.00
Overhead charges, selling, and depreciation, 50 tons, at $1	50.00
Total	450.00
Freight to eastern centers, at $6	300.00
	750.00

The proceeds from the sale of the product may be estimated as follows:

On basis of retail sales, 50 tons, at $22.94	$1,147.00
On basis of wholesale sales, 50 tons, at $16.45	822.50

An estimate of daily profits may be made as follows:

Retail basis:	
Daily proceeds	$1,147.00
Daily expenditures	750.00
Daily profits	397.00
Profits for 30 days' operation	11,910.00
Wholesale basis:	
Daily proceeds	822.50
Daily expenditures	750.00
Daily profits	72.50
Profit for 30 days' operation	2,175.00

While very great accuracy can not be claimed for these estimates, as they are based on experience with materials other than kelp, it is

believed that they are approximately correct and can be taken as an indication of what the items of expenditures and proceeds may be. They indicate strongly that a plant erected and equipped for rendering cannery waste can be applied with profit to the treatment of kelp. The proviso that the plant be equipped with a drier of large capacity must be introduced. In the beginning of the proposed industry the market on the Pacific coast would consume the entire product, so that the high freight rates to the Atlantic seaboard could be avoided. This would add materially to the profits.

The products of the proposed combined fish-rendering and kelp-drying plant may be disposed of separately to mixers of fertilizers, or they may be mixed and retailed directly to the consumers as so-called complete fertilizers. The mixture of fish scrap and dried kelp would contain ammonia, potash, and phosphoric acid (bone phosphate), the three substances regarded as essential ingredients of a complete fertilizer. Mixed in equal proportions, the analysis of the product would approximate 5 per cent nitrogen, 3.5 per cent phosphoric acid, and 7 per cent potash. Such a fertilizer, from the conventional point of view, would be regarded as deficient in phosphoric acid, that ingredient being added usually in larger proportion than the potash or nitrogen. To make it conform to that formula, acidulated phosphate rock could be added. However, this ratio is purely conventional and may be disregarded.

FISH SCRAP FROM OTHER FISH.

It has been shown that at present about 1,630 tons of dried fish scrap represents the annual output of that product from the refuse from the salmon industries. In addition thereto, small quantities of scrap are produced from the herring, tuna, and whale fisheries, and a considerable waste is discarded in the halibut fisheries.

HERRING.

At Killisnoo, Alaska, is the only fertilizer plant on the coast using herring as its raw material. The company operating the plant was organized in 1889. In 1909 the plant was equipped with new and improved apparatus. The methods in vogue are the same as those employed in the menhaden industry on the Atlantic coast.

The Killisnoo plant uses about 40,000 barrels of 200 pounds each of raw herring per year, from which about 1,000 tons of dry scrap and 3,500 barrels of oil are yielded.

The herring utilized are obtained in the waters of and adjacent to southeastern Alaska. In the same region there has been developed a small herring fishery which salts herring for the market. This industry, presumably, is only in its infancy. However, at present

the Alaska herring are not in demand, bring a low price, and exhibit poor keeping properties.

During the year 1913 about 6,000,000 pounds of herring were prepared for use other than in the manufacture of fertilizer. This application of herring is itemized in the following table:[1]

TABLE XV.—*Use of herring other than for fertilizer.*

Application.	Quantity.	Value.
	Pounds.	*Dollars.*
Fresh, for bait	3,936,500	22,245
Frozen, for bait	231,935	2,291
Pickled, for food	692,400	26,832
Pickled, for bait	256,200	3,297
Dry salted, for food	5,259,520	50,183
Smoked, for food	17,371	1,257
Total	10,393,926	106,105

Even in the present stage of development of the herring-salting and herring-fertilizer industries, the two are supposed to be in conflict with each other, and it is being proposed that the fertilizer industry be suppressed. Since the food demands of the Nation must take precedence over all others, if the manufacture of fertilizer from herring is bringing about such a depletion of the supply of these fish that the demands for them as a food fish are not satisfied, it is fitting that the former use be restricted or suppressed. There seems to be no authentic information substantiating the belief entertained by some that the herring-salting industry is suffering from the activity of the herring-fertilizer industry. In fact, when the herring fisheries of Alaska are compared with those of the northern shores of the Atlantic, it is seen that the total number caught there is insignificant; about 22,000,000 pounds are utilized in Alaska for all purposes, while in the north Atlantic, about 900,000,000 pounds are utilized.

Obviously, it is greatly to the advantage of the Nation that the fish of the sea be put to some use. Their application to the soil as fertilizer is only one step removed from their direct utilization as food, since when so used they go to increase the food supply. Their utilization in this manner is very much more to the advantage of everyone concerned than putting them to no use whatever. Ultimately, the fish resources of the country will be developed to their fullest economical usefulness, when they will be drawn upon to supply man with greatly increased amounts of food. Until such a time they should be open to supervised use in whatever way industry demands.

[1] From Bower and Fassett, loc. cit.

In this connection the opinion of the experts of the United States Bureau of Fisheries is of interest:

The concensus of opinion is that herring have been more numerous this season in the water of Alaska, except in the Yes Bay section, than for a number of years past. At no time heretofore has there been anything like an alarming shortage, but as in the case of herring fishery the world over, there are periodical lean and full years. It not infrequently happens that during the poorer years alarmists give rise to the view that the supply of herring is being diminished through ruthless fishing operations. Particularly has this idea been directed toward the practice of utilizing herring in the manufacture of fertilizer and oil. That this opinion is not borne out in fact has been clearly established by careful and impartial analysis of the situation. So far as Alaska is concerned, the destruction of countless millions of herring in embryo by the natives, who use large quantities of impregnated eggs for food purposes, is a more destructive agency than the use of the adult fish for fertilizer purposes. Measures should be adopted to prohibit the natives from placing brush on the spawning grounds by means of which they remove the eggs.

The halibut fishermen are particularly interested in the herring situation, because of the dependence of their industry upon the supply of herring for bait. Much of the agitation as to the fertilizer and oil question has emanated from this source. Unless future developments show radically different conditions, as compared with other parts of the world where time has been the infallible test, there will be not only enough herring in Alaska waters to meet present-day needs, both for bait and fertilizer, but to permit of an expansion along these lines, as well as a growth of the food-herring industry.[1]

In the face of the present successful opposition, however, it seems scarcely reasonable to believe that there will be any further development in the manufacture of fertilizer from herring.

During the season of 1913 Alaska herring yielded 1,200 tons dried fertilizer and 260,000 gallons of oil. For this purpose 57,800 barrels of 200 pounds each of raw herring were rendered.

TUNA.

The canning of California tuna, or more properly, the Albicore, is a development of only recent years. At present it is carried on by about nine canneries in southern California, the center of the industry being San Pedro. The output for the year 1913 amounts to about 115,000 cases.

The waste from the tuna is very large. The fish are dressed, as caught, at sea and the waste thus produced is thrown overboard. This represents about 20 per cent of the fish. After delivery at the cannery it is cooked, when its weight decreases about 18 per cent, due to loss in the removal of oil and soluble constituents. After cooking, the bones, skin, and dark-colored flesh are removed, representing a further loss of about 32 per cent. The total loss from the round weight of the fish to the finished product is about 70 per cent.

[1] From Bower and Fassett, loc. cit.

Present practice makes the greater part of this available for the manufacture of fertilizer. Since the material is cooked before discarding, some of the oil has been released, thus detracting from the value of the material as a source of oil. What proportion of oil thus is lost can not be said. It is probable that only a little more cooking is necessary to render the material suitable for pressing.

At present a considerable part of the cooked meats (about 500 tons per year) is disposed of for the manufacture of fertilizer. To effect this the waste is only dried in a steam drier, no attempt being made to recover the oil present. During the season of 1913 about 50 tons of tuna fertilizer were prepared. A sample of this was analyzed by J. R. Lindemuth, the results of which are given in Table XVI.

The tuna-canning industry shows promise of development. The fine qualities of the product have brought it into demand. The present pack represents an initial or round weight of 16,400,000 pounds. If all the waste from this (70 per cent) were saved, it would yield about 5,700 tons, or if only that produced at the canneries were saved it would amount to about 4,000 tons of undried scrap.

HALIBUT.

Halibut are caught by hook and line, trawl, or "ground line." At the end of each day's fishing the catch is partially dressed, the viscera being removed, and is packed in ice for transportation to the halibut stations for the final preparation for market. The waste produced in the preliminary dressing is thrown overboard. At the halibut stations, generally fish-freezing stations, the heads are severed and the fish are subjected to a final cleansing before being frozen for storage or shipment. The heads represent about 14 per cent of the weight of the fish as delivered at the stations. The present practice is to throw these into the water at the stations, at the end of the day's work, in the manner most convenient. As the greater portion of the halibut caught are marketed fresh or frozen, they are shipped whole without further cutting, with the result that the only waste from them produced at the stations is the heads.

During the past season (1913) the Alaska halibut fisheries produced 13,437,800 pounds of halibut. This is the weight of the prepared fish. In producing this weight, about 1,100 tons of heads were discarded, and probably an equal weight of viscera. To preserve the latter and make it available for rendering the oil and preparing the residue for fertilizer, the fishing boats would have to be equipped with ice-cooled tanks for receiving the viscera. This would be objected to on the part of the operators, as frequently all available space on the fishing steamers is taxed to its utmost to accommodate the fish of far greater value than the viscera. It is

doubtful, therefore, whether any economical method of preserving this waste could be devised. The heads, on the other hand, easily could be saved, provided the halibut stations were within a convenient distance of a rendering station. At best these could be regarded only as a small auxiliary supply of raw material, for in no instance, probably, is there a sufficient quantity of heads produced at any one station to warrant the installation there of a by-products plant.

The fish taken incidentally in the halibut fisheries constitute another large waste. Concerning this, Messrs. Bower and Fassett, of the United States Bureau of Fisheries say:

> Halibut are almost exclusively caught on trawl or ground lines, which, equipped with hundreds of hooks, are set out from dories in great lengths over the bottom. At intervals, as the weather permits, the lines are underrun, the catch removed, hooks rebaited, and the lines reset, this work also being done from dories. After careful inquiry among halibut fishermen themselves, it is believed to be a safe estimate that for every halibut caught at least one other fish of more or less value as food is taken from the hooks. With those rare exceptions when black cod are retained, all these fish are thrown back into the sea, either dead or soon to perish. Except in so far as they may become food for other species, they may be regarded as a total economic loss.[1]

There is little information on which to base an estimate of the weight of the other fish taken with the halibut. Assuming that this is only 25 per cent of the round weight of the halibut, about 16,000,000 pounds, it would amount to 2,000 tons waste fish. To conserve this for rendering it would be necessary to equip the steamers with storage tanks, which, it has been pointed out, would be regarded as highly objectionable, owing to lack of space. At the present low price which such material brings in the market and the short time in which rendering plants would be in operation, it seems quite improbable that the waste produced in the halibut fisheries will come to play an important rôle as a source of raw materials for the manufacture of fertilizer and oil.

WHALE.

Whaling from shore stations has been reduced to the extent that only two such stations were operated on the Pacific coast territory of the United States during the 1913 season. These were the stations at Port Armstrong, Alaska, and Bay City, Wash. At the former station 186 whales were taken,[2] which yielded 665 tons of fertilizer. At the latter plant about 500 tons of fertilizer and bone meal were prepared. The composition of these products is shown in Table XVI.

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[1] Pacific Fisherman, 12, No. 1 (special), 1914 cf., p. 63.
[2] Bower and Fassett, loc. cit.

Since the whaling industry has undergone a large decline through the depletion of the number of whales, there is little probability that the future will see any marked increase in the production of fertilizer from whale carcasses.

In the following table are reported results of analysis of material prepared from the waste from the sardine, tuna, and whale industries and from dog fish:

TABLE XVI.—*Analysis of dried fish scrap from fish other than salmon.*

[J. R. Lindemuth, analyst.]

Type of fish.	Location.	Nitrogen.	Phosphoric acid (P_2O_5).	Moisture.	Oils.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
Sardine	Monterey Packing Co., Monterey, Cal.	7.97	7.11	5.57	8.42
Whale meal	Canadian North Pacific Fisheries (Ltd.), Victoria, British Columbia.	11.59	.94	5.41	12.70
Whale bone meal	do	3.01	26.08	2.53	Trace.
Tuna	San Pedro Fertilizer Co., San Pedro, Cal.	8.54	7.25	4.21	13.27
Dogfish	Pacific Products Co., Port Townsend, Wash.	12.15	3.59	6.35	7.89

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